

D E C L A R A T I O N

I, SHINICHI USUI, a Japanese Patent Attorney registered No.9694, of Okabe International Patent Office at No. 602, Fuji Bldg., 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain a correct translation into English of the priority documents of Japanese Patent Application No.2002-340304 filed on November 25, 2002 in the name of CANON KABUSHIKI KAISHA.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 8th day of November, 2004



SHINICHI USUI

PATENT OFFICE  
JAPANESE GOVERNMENT

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[TITLE OF THE INVENTION] PHOTOVOLTAIC POWER  
GENERATING APPARATUS

[CLAIM]

5 [CLAIM 1] A photovoltaic power generating apparatus comprising a single solar cell element formed on a substrate and a plurality of power conversion devices connected to the solar cell element for converting an output of the solar cell element.

10 [DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of the Invention]

The present invention relates to a photovoltaic power generating apparatus, photovoltaic power generating system and method of producing the photovoltaic power generating apparatus, and more particularly to a photovoltaic power generating apparatus comprising only a single solar cell element connected to a plurality of power conversion devices, a photovoltaic power generating system using the same and a method of producing the photovoltaic power generating apparatus.

[0002]

[Prior Art]

25 In recent years, with the emergence of serious problems such as global warming due to emission of carbon dioxide, etc., caused by use of fossil fuel

and pollution with radioactivity by accidents at atomic power plants and nuclear waste, there is a glowing concern about global environment and energy. Under such circumstances, solar photovoltaic power generation using solar radiation, geothermal power generation using geothermal power and wind power generation using wind power, etc., are being put to practical use worldwide as inexhaustible and clean energy sources.

10 [0003]

Of these energy sources, there are various modes of solar photovoltaic power generation using a solar cell according to an output scale from several W to several thousand kW. A typical system using a solar cell 15 is a photovoltaic power generating system that converts DC power generated by the solar cell to AC power (DC-AC conversion) by an inverter, etc., and supplies the power generated to a load of a demander or a commercial power system (hereinafter simply referred to as "system").

20 [0004]

FIG. 2 shows a schematic configuration of a conventional, general photovoltaic power generating system. As shown in the figure, the photovoltaic power generating system 8 generally uses a solar cell module 6 made up of a plurality of serially connected solar cell elements as a unit, forms a solar cell

string 7 (also called as a "solar cell array") made up of a plurality of the serially connected solar cell modules 6, further forms a solar cell array made up of a plurality of those solar cell strings 7 5 connected in parallel, collects DC outputs from the solar cell arrays by a current collection box 9, converts the collected power to AC power by an inverter 3 and interconnects the AC power with a load 4 or commercial system 5.

10 [0005]

In such a photovoltaic power generating system 8, when outputs of the plurality of solar cell strings 7 vary from one string to another due to influences such as a variation in output characteristics of the 15 solar cell or partial shadows of buildings, etc., the photovoltaic power generating system 8 may not be able to operate at optimal power points.

[0006]

In order to cope with this problem, Patent 20 Document 1 discloses a photovoltaic power generating system which provides a DC-DC converter through a connection box for each solar cell array, inputs DC output power to an inverter all together and converts the DC power to AC power. In this configuration, each 25 DC-DC converter performs maximum power point tracking control over the solar cell array connected thereto, and thereby improves the accuracy of the maximum

power point tracking control over the photovoltaic power generating system.

[0007]

Furthermore, Patent Document 2 discloses the 5 possibility of increasing or decreasing an amount of power generated by a solar cell at low costs by providing an inverter for each solar cell array, solar cell module or solar cell element, thereby reducing variations in output or difference in power 10 efficiency due to partial shadows among solar cell arrays, solar cell modules or solar cell elements and providing an inverter for each solar cell module or solar cell element.

[0008]

15 However, in the photovoltaic power generating system described in Patent Document 1 which inputs DC outputs of the solar cell arrays or solar cell modules to a DC-DC converter, it is necessary to serially connect a plurality of solar cell elements 20 to create a solar cell module.

[0009]

Generally, creating a solar cell module requires quite many steps including a cutting step for dividing a photovoltaic layer stacked on a substrate 25 into solar cell elements, an end etching step for providing a non-power generating area for insulating from one solar cell element to another, a step of

serially connecting the solar cell elements one by one using a wiring member such as an inter-connector, a step of connecting a bypass diode to reduce influences of partial shadows, a step of coating a 5 group of serially connected solar cell elements and a step of fitting a frame at an end of the coated group of solar cell elements, and thereby takes time and uses costly members, which constitute factors responsible for increasing the price of a 10 photovoltaic power generating apparatus.

[0010]

Especially when a solar cell module having a large area is produced, the step of serially connecting many solar cell elements takes time and 15 trouble, which constitutes a serious problem in producing a solar cell module having a large area.

[0011]

Furthermore, a configuration of solar cell elements serially connected using a wiring member 20 such as an inter-connector requires a gap to insert the inter-connector between solar cell elements, the number of such gaps increases as the number of serially connected solar cell elements increases, which entails an increase in the non-power generation 25 area not used for power generation in the solar cell module. As a result, the efficiency of area power generation of the solar cell module reduces.

[0012]

In addition, since the solar cell elements are serially connected, influences of partial shadows on the power generation efficiency also increases. For 5 example, if one of the serially connected solar cell elements is covered with a partial shadow, the current generated from the cell reduces and the rates of currents generated from other cells are also limited by this cell.

10 [0013]

Reducing the influence of this partial shadow requires a bypass diode to be connected in parallel to each of the serially connected solar cell elements. However, even using this method cannot completely 15 eliminate the influences of the partial shadow on other power generating cells.

[0014]

Furthermore, as described in Patent Document 2, providing an inverter for each solar cell element may 20 alleviate work in the serial connection step which is the above described problem, but this requires a cutting step and an etching step at the ends of individual solar cell elements when creating those solar cell elements, which still takes time and 25 trouble.

[0015]

Furthermore, when a structure of mounting solar

cell elements on a support is adopted, it is necessary to precisely locate those solar cell elements at certain intervals to improve electric insulation between the respective solar cell elements,  
5 the external appearance and efficiency of area power generation, which is however a difficult task and constitutes a factor responsible for a cost increase.

[0016]

Patent Document 3 discloses a solar cell module  
10 comprising individual solar cell elements, each of which is formed on a single substrate, all connected in parallel as a solution to all the above described problems such as complicated step of serial connections, cost increase, influences of partial  
15 shadows and difficulty in mounting work.

[0017]

This solar cell module is constructed in such a way that a current collection bus bar is connected to a current collection electrode of each solar cell  
20 element and a plurality of outputs of the solar cell elements are collected into a single output.

[0018]

However, in such a configuration, the value of the current flowing through the current collection  
25 bus bar is the sum of the plurality of output currents of the solar cell elements, causing another problem that as the number of solar cell elements

increases and the area of the solar cell module increases, loss in current collection also increases considerably.

[0019]

5 To solve the problem of this current collection loss, the cross section of the current collection bus bar may be increased, but this solution causes the weight and volume of the current collection bus bar to grow considerably, making the  
10 producing/transporting work difficult.

[0020]

[Patent Document 1]

Japanese Patent Application Laid-Open No. 2000-112545

[Patent Document 2]

15 Japanese Patent Application Laid-Open No. H08-70533

[Patent Document 3]

U.S. Pat. No. 4,773,944

[0021]

[Problems to Be Solved by the Invention]

20 The present invention has been implemented taking into account the above described circumstances and it is an object of the present invention to provide a photovoltaic power generating apparatus of a simple configuration capable of reducing a  
25 production cost, reducing influences of partial shadows and variations in its characteristics, photovoltaic power generating system using the

photovoltaic power generating apparatus and a method of producing the photovoltaic power generating apparatus.

[0022]

5 [Means for Solving the Problems]

The constitution of the present invention accomplished for solving the above object is as follows.

[0023]

10 That is, a first aspect of the invention is a photovoltaic power generating apparatus comprising a single solar cell element formed on a substrate and a plurality of power conversion devices connected to the solar cell element for converting an output of  
15 the solar cell element.

[0024]

In the photovoltaic power generating apparatus according to the first aspect of the invention, the following features may be adopted preferably.

20 "The plurality of power conversion devices are DC-DC converters for boosting a DC voltage output from the solar cell element";

"The plurality of power conversion devices are inverters";

25 "A wiring member electrically connecting the solar cell element and the power conversion device has an exposed live section in at least a part

thereof";

5        "The solar cell element comprises a photoelectric conversion layer, a current collection electrode disposed on a light-receiving surface side of the photoelectric conversion layer, a surface wiring member, and a transparent thin film resin layer, wherein at least a part of the current collection electrode or the surface wiring member has an exposed section which is not covered with the 10 transparent thin film resin layer";

      "The photoelectric conversion layer comprises thin film silicon";

15        "The substrate is conductive and a substrate side of the photoelectric conversion layer constitutes a positive electrode";

      "The substrate is conductive and one of outputs of the solar cell element and one of outputs of the DC-DC converter are electrically connected to the substrate";

20        "One of outputs of the solar cell element and one of outputs of the DC-DC converter are on a low voltage side";

25        "One of outputs of the solar cell element and one of outputs of the DC-DC converter are on a high voltage side";

      "The solar cell element has a portion where no power generation section is formed on two peripheral

sides thereof";

"The solar cell element is fixed to a support through the portion where no power generation section is formed"; and

5        "The solar cell element or the photovoltaic power generating apparatus itself is encapsulated with a resin."

[0025]

A second aspect of the present invention is a  
10      photovoltaic power generating system comprising one or more of the photovoltaic power generating apparatus according to the first aspect of the invention wherein the plurality of power conversion devices are DC-DC converters for boosting a DC  
15      voltage output from the solar cell element, and an inverter for converting outputs thereof to AC power and supplying the AC power to a load or interconnecting the AC power to a commercial power. In this case, it is preferred that the inverter has  
20      an insulating transformer, and a wiring member connecting the DC-DC converter and the inverter is grounded.

[0026]

A third aspect of the present invention is a  
25      photovoltaic power generating system comprising one or more of the photovoltaic power generating apparatus according to the first aspect of the

invention wherein the plurality of power conversion devices are inverters, wherein the plurality of inverters supply the output power to a load or interconnect the output power with a commercial power system.

5 [0027]

A fourth aspect of the present invention is a method of producing a photovoltaic power generating apparatus comprising the steps of forming a solar cell 10 element on a substrate through a semiconductor producing step and connecting a plurality of power conversion devices to predetermined portions of the solar cell element. In this case, it is preferable to form a photoelectric conversion layer, a current 15 collection electrode and a surface wiring member on the substrate successively to thereby form a solar cell element and connect the power conversion devices to predetermined portions of the solar cell element successively.

20 [0028]

According to the present invention, because a photovoltaic power generating apparatus is constructed using only a single solar cell element formed on a substrate, those steps including cutting, 25 end etching, serial connection, and bypass diode connection required for production of the conventional, general solar cell modules become

unnecessary, which leads to reductions of production and material costs and improvement in the efficiency of area power generation of the photovoltaic power generating apparatus.

5 [0029]

Furthermore, there is no need for the work of mounting solar cell elements at regular intervals on the support and it is possible to mount a photovoltaic power generating apparatus as a unit, 10 thereby drastically shortening the time required for mounting the photovoltaic power generating apparatus and reducing the cost required for the mounting.

[0030]

In addition, the influences of partial shadows 15 are limited only to the power conversion devices involved in the shadowed areas and have no influence on other power conversion devices. Furthermore, since only a single solar cell element is formed on the substrate, the variation in the electric 20 characteristics of the solar cell in the photovoltaic power generating apparatus is also small. Therefore, it is possible to drastically reduce influences of partial shadows and variations in the characteristics compared with a conventional system having serially 25 connected solar cell elements.

[0031]

[Embodiments]

With reference now to the attached drawings, embodiments of a photovoltaic power generating apparatus and a photovoltaic power generating system according to the present invention will be explained 5 in detail below.

[0032]

(First embodiment)

FIG. 1 is a schematic view showing a configuration of a photovoltaic power generating 10 system according to a first embodiment of the present invention. Reference numeral 1 denotes a single solar cell element formed on a conductive substrate, 2 denotes a DC-DC converter, 3 denotes an inverter, 4 denotes a load and 5 denotes a commercial system.

15 [0033]

The term "solar cell element" used herein refers to a certain area having a photovoltaic layer segmented by etching lines, etc., which is a minimum unit having the function as a solar cell capable of 20 extracting electric power therefrom.

[0034]

Here, DC power output from the solar cell element is input to DC-DC converters 2 provided on the solar cell element at predetermined intervals, 25 boosted to a voltage at a predetermined boosting rate, these outputs are input to the inverter 3 all together, converted to AC power at a commercial

frequency, supplied to the load 4 and extra electric power is sent to the commercial system 5.

[0035]

5 Hereinafter, the apparatus made up of the solar cell element 1 and the plurality of DC-DC converters 2 connected to the solar cell element will be called a "photovoltaic power generating apparatus 106."

[0036]

10 The components used in the photovoltaic power generating apparatus and the photovoltaic power generating system according to this embodiment will be explained in detail below.

[0037]

(Solar cell element)

15 FIG. 3 is a cross sectional view showing a layered configuration of the solar cell element 1 formed on a conductive substrate, consisting of a lower electrode layer 11, a semiconductor layer 12, an upper electrode layer 13 stacked on a conductive 20 substrate 10. The lower electrode layer 11 may be omitted depending on the configuration of the conductive substrate 10.

[0038]

25 Here, as the conductive substrate 10, a substrate which is wound like a roll beforehand is preferable and it is preferable from the standpoint of productivity to stack the above described layers

while feeding this substrate one by one and rewind it at the other end to create the conductive substrate according to a continuous film formation method such as a roll-to-roll method, and a case where this 5 method is used will be principally explained here. Of course, a batch system apparatus can also be used.

[0039]

The lower electrode layer 11, semiconductor layer 12 and upper electrode layer 13 are described 10 in detail in Japanese Patent Application Laid-Open No. 11-186572 to the assignee of this application. Since these components are not essential parts in the present invention, detailed explanations will be omitted.

15 [0040]

As the semiconductor layer 12, thin film silicon is preferable and amorphous silicon is particularly preferable and when amorphous silicon is used as a semiconductor layer, a pin junction is normally used 20 in which an n-type semiconductor, an i-type semiconductor and a p-type semiconductor are stacked in that order from the conductive substrate 10 side.

[0041]

Moreover, it is also preferable to use a double 25 or triple configuration in which two or three layers of the above described pin junction or pn junction are stacked.

[0042]

Furthermore, this embodiment also preferably uses nip junction consisting of a p-type semiconductor, an i-type semiconductor and an n-type semiconductor stacked in that order from the conductive substrate 10-side depending on the case.

[0043]

Furthermore, as a film formation method of each layer, a vapor deposition method, sputtering method, high-frequency plasma CVD method, micro-plasma CVD method, ECR method, thermal CVD method, LPCVD method, etc., can be selected from various methods which are publicly known and publicly used as appropriate.

[0044]

Then, in order to cut and divide the solar cell stacked body formed in this way into desired lengths, an etching paste containing  $\text{FeCl}_3$ ,  $\text{AlCl}_3$ , etc., is applied to the upper electrode layer using a screen printing method in such a way that short-circuit between the conductive substrate and upper electrode layer produced by division/cutting does not affect the effective light-receiving area, the etching paste is heated and then cleaned, part of the upper electrode layer of the solar cell stacked body is thereby removed linearly to form etching lines 115 such as shown in FIG. 4.

[0045]

Then, as shown in FIG. 4, an insulating double-side adhesive tape 25 is continuously pasted to one side of the light-receiving surface of the conductive substrate, current collection electrodes 14 are 5 formed on the insulating double-side adhesive tape 25 and upper electrode at predetermined intervals. Furthermore, a light-receiving surface terminal member 16 is attached on the top of the insulating double-side adhesive tape 25 by heating/pressure 10 bonding. The current collection electrodes 14 used here will be explained in detail later.

[0046]

In the above-described steps, a solar cell assembly 401 provided with the current collection electrodes 14 and light-receiving surface terminal member 16 as shown in FIG. 4 is produced. 15

[0047]

Then, as shown in FIG. 5, a transparent thin film resin layer 23 is stacked on the light-receiving 20 surface of the solar cell assembly 401 to form a solar cell assembly 501. Here, this is called a solar cell assembly in the present specification irrespective of the presence/absence of the transparent thin film resin layer 23, and as will be 25 described later, one obtained by cutting a solar cell assembly will also be called a solar cell element irrespective of the presence/absence of the

transparent thin film resin layer. The configuration and method of forming this transparent thin film resin layer will be described in detail later.

[0048]

5        When the transparent thin film resin layer 23 is formed, it is preferable to form the solar cell assembly 501 by forming the transparent thin film resin layer 23 not over the entire light-receiving surface but only part thereof. Such a configuration  
10      eliminates the need for an extra insulating material and therefore decreases the cost of the photovoltaic power generating apparatus and the entire system.

[0049]

More specifically, for example, instead of  
15      providing the transparent thin film resin layer 23 over the entire surface of the solar cell assembly 401, the transparent thin film resin layer 23 is applied to only the minimum necessary portion to prevent influences on the power generation  
20      performance in an outdoor environment. That is, without forming the transparent thin film resin layer 23 on the light-receiving side terminal member 16 or etching lines 115, it is possible to coat only the portion (active area) having photoelectric conversion  
25      characteristics for at least incident light of the solar cell element.

[0050]

Then, the solar cell assembly 501 on which the above described transparent thin film resin layer 23 is stacked is cut along the above described etching lines 115 to a desired length to form the solar cell element 1. Furthermore, by arranging a plurality of DC-DC converters 2, which will be described later, at predetermined intervals in the solar cell element 1 and electrically connecting them, it is possible to construct the photovoltaic power generating apparatus 106 as shown in FIG. 1. In this case, the solar cell assembly 501 is also possible to be cut after the DC-DC converters 2 are connected thereto.

[0051]

Adopting such a configuration of the photovoltaic power generating apparatus eliminates etching lines for dividing the solar cell elements between the DC-DC converters, increases the area of the active area and has the effect of improving the efficiency of area conversion of the solar cell.

[0052]

It is also possible to protect the solar cell element 1 from the outdoor environment by sealing it with a weather resistant film, filler and back reinforcement member, etc., in the next step as in the case of a conventional solar cell module and the solar cell element in this configuration can also be used in the present invention in the like manner.

[0053]

Then, the components of the solar cell element 1 of this embodiment will be explained in detail below.

[0054]

5 (Conductive substrate)

The conductive substrate 10 used in the solar cell element according to this embodiment is a member to mechanically support the semiconductor layer for photoelectric conversion and can also be used as the 10 electrode on the non-light-receiving side of the solar cell element. As such a substrate, it is preferable to use a heat resistant substrate that can withstand a heating temperature when the semiconductor layer is formed.

15 [0055]

Furthermore, since the conductive substrate is the part to be adhered when the solar cell element is adhered to the support such as a concrete block, it is preferable to use a material having good 20 adhesiveness with the adhesive used.

[0056]

Furthermore, when the conductive substrate is fixed to the support using a fixing member, the conductive substrate preferably has mechanical 25 strength to withstand the fixing, weather resistance and corrosion resistance.

[0057]

As the material for the conductive substrate, for example, metal such as Fe, Ni, Cr, Al, Mo, Au, Nb, Ta, V, Ti, Pt and Pb, etc., or an alloy of these metals, for example, brass, thin plate such as 5 stainless steel or their composite, carbon sheet, zinc-plated steel plate, etc., can be used.

[0058]

As the substrate, it is also possible to use an electrical insulating material, a heat-resistant 10 synthetic resin film or sheet such as polyester, polyethylene, polycarbonate, cellulose acetate, polypropylene, polyvinyl chloride, polyvinylidene chloride, polystyrene, polyamide, epoxy, etc., or a composite of them with glass fiber, carbon fiber, 15 boron fiber, metal fiber, and thin plate thereof, resin sheet, on the surface of which a metal thin film of different material is vapor-deposited or stacked.

[0059]

20 (Current collection electrode)

The current collection electrodes 14 are generally formed in a comb-like shape on the semiconductor layer or the upper electrode layer of the solar cell element and preferable width and pitch 25 are determined from the value of sheet resistance of the semiconductor layer or upper electrode layer.

[0060]

Furthermore, the current collection electrodes are required to have low resistivity and not to constitute serial resistance of the solar cell and preferable specific resistance is  $10^{-2}$   $\Omega\text{cm}$  to  $10^{-6}$   $\Omega\text{cm}$ .

5 As the material for the current collection electrodes, for example, metal such as Ti, Cr, Mo, W, Al, Ag, Ni, Cu, Sn or Pt or an alloy of these metals or solder or a metal wire to the surface of which a conductive adhesive is applied are used. Generally, a metal 10 paste in which metal powder and polymer resin binder are formed in a paste form is used, but the material is not limited to this.

[0061]

(Terminal member)

15 The terminal member 16 is a member that is electrically connected to the current collection electrodes 14 to form a positive or negative lead electrode. This terminal member 16 is attached to the conductive substrate or the etching surface with the 20 upper electrode layer of the solar cell element removed using laser welding, a conductive adhesive, brazing, etc., so as to provide electrically low resistance and attached mechanically strongly. Or the terminal member 16 is attached to the current 25 collection electrodes by pressing. The present Specification distinguishes between a "light-receiving surface terminal member" and "non-light-

receiving surface terminal member" according to the position of the solar cell element on which the terminal member is attached.

[0062]

5        The electric performance and material, etc., required for the terminal member are almost the same as those of the above described current collection electrode, but the terminal member preferably has a foil shape to keep flatness of the solar cell element  
10      and allow low resistance.

[0063]

It is also possible to spread the non-light-receiving surface terminal member over the entire non-light-receiving surface in a comb-like shape or  
15      radially to thereby improve the current collection efficiency.

[0064]

Furthermore, when a terminal member for a connection with the DC-DC converters or the inverter  
20      is necessary, the terminal member is attached and drawn out to the light-receiving surface terminal member or non-light-receiving surface terminal member using a method like laser welding, a conductive adhesive or brazing, etc.

25      [0065]

(Transparent thin film resin layer)

The transparent thin film resin layer 23

positioned on the light-receiving surface of the solar cell element in this embodiment is not limited to a particular resin layer if it is at least transparent and allows the current collection 5 electrodes, upper electrode layer, etc., therebelow to be covered and protected. However, the transparent thin film resin layer preferably has excellent applicability, weather resistance and adhesiveness and is particularly required to have excellent water 10 resistance.

[0066]

As a specific material, fluororesin, acrylic resin, polyester, polycarbonate, etc., can be used. More specifically, polyvinylidene fluoride (PVDF) 15 resin, polyvinyl fluoride (PVF) resin or tetrafluoroethylene-ethylene copolymer (ETFE) resin, etc., is available. From the standpoint of weather resistance, polyvinylidene fluoride resin is excellent, but from the standpoint of compatibility 20 between weather resistance and mechanical strength and transparency, tetrafluoroethylene-ethylene copolymer is excellent. Furthermore, to realize a further cost reduction, use of a non-film material 25 such as acrylic resin-based or fluororesin-based transparent paint is preferred. In this case, a coating method such as curtain coating used for normal applications is used.

[0067]

From the requirements in production steps, as the resin paint capable of using a curtain flow coating method, it is preferable to use paint having 5 a viscosity as low as 0.3 Pa·s or less. Furthermore, from the standpoint of further improving productivity, a spray coating method is preferable and in this case, a resin paint having a low viscosity of 0.05 Pa·s or less is preferable.

10 [0068]

As a lower limit of viscosity, there is no particular limitation and any appropriate viscosity can be selected based on the desired film thickness. However, as the viscosity decreases, a plurality of 15 times of painting are required to form a required film thickness, and therefore it is actually preferable to have a viscosity of 0.001 Pa·s or more.

[0069]

With regard to the thickness of the transparent 20 thin film resin layer 23, a thickness of 1  $\mu\text{m}$  or more is preferable as the thickness to which the paint is applicable without pinholes and approximately 200  $\mu\text{m}$  or less is preferable from the following standpoint.

[0070]

25 From the standpoint of coating and protecting the current collection electrode, upper electrode layer or photovoltaic layer with a transparent thin

film resin layer, a thicker one is preferable. However as the thickness increases, sunlight penetrates the transparent thin film resin layer less and the power generation performance deteriorates.

5 Furthermore, forming a thick layer may deteriorate flexibility of the resin layer. Moreover, as the thickness increases, the current collection electrode, upper electrode layer or photovoltaic layer may be destroyed by contraction during hardening and when

10 used outdoors, if the resin layer is as thick as 200  $\mu\text{m}$  or more, it is no longer possible to follow forces of thermal expansion or forces applied at the time of mounting and the resin layer may have cracks caused by stress or peel off in the interface with the

15 current collection electrode, upper electrode layer or photovoltaic layer.

[0071]

However, the transparent thin film resin layer need not always be formed only of one kind material

20 and may be constituted of, for example, two layers formed using two kinds of materials. In this case, it is possible to select a material having good adhesiveness with the upper electrode layer right above the upper electrode layer of the solar cell

25 element and select a material having excellent weather resistance on top of it. A typical formation method in this case may be to perform the application

step twice.

[0072]

(Parallel connection member)

Constructing the photovoltaic power generating  
5 apparatus in this embodiment requires parallel  
connections between the DC-DC converters respectively  
connected to the solar cell element. The member used  
to make these connections is a parallel connection  
member. When the conductive substrate in the solar  
10 cell element is used as a common terminal on one side,  
this member is used only for the electrode on one  
side.

[0073]

More specifically, this is the member to connect  
15 the output terminals on one side of the respective  
DC-DC converters 2 and a general-purpose insulated  
electric wire or insulated cable, etc., can also be  
used, but bare conductive wires without any  
insulating coating can also be used as an example  
used in this embodiment. A copper wire, copper  
20 twisted wire or copper band, etc., is preferable as  
the bare conductive wire.

[0074]

(Inter-device connection member)

25 In this embodiment, the connection member  
between the DC-DC converters 2 and the inverter 3 is  
defined as an inter-device connection member. As the

inter-device connection member, one with the same shape and material as those for the above described parallel connection member can be used. It is also possible to extend the parallel connection member 5 used for a connection between the DC-DC converters and connect it to the inverter and use it as a substitute for the inter-device connection member.

[0075]

(Support)

10 The support refers to a member that fixes the solar cell element and is generally a frame or a member that forms the mounting surface.

[0076]

15 There is no limitation to the means for fixing the solar cell element to the support, but a fixing method using an adhesive is preferable because it requires only a small area of the non-power-generation area in the solar cell element.

20 Furthermore, it is also possible to provide a non-power-generation area for mounting in part of the solar cell element and fix that part using fixing members such as nails, screws, and bolts.

[0077]

25 For simplicity of structure and ease of mounting work, it is preferable to use a concrete material in this embodiment. This is because if the support is a heavy material such as concrete, simply placing the

support completes the placement of the support (frame). Moreover, concrete has excellent outdoor durability, is inexpensive and convenient to be used as a frame of the solar cell.

5 [0078]

Furthermore, it is preferable to construct the support by dividing, for example, a fixed support (support) having, for example, a tabular shape for fixing the solar cell and a back support for mounting 10 this fixed support separately. This is because the mounting angle of the solar cell can be changed arbitrarily by mounting the back support having a cubic shape, etc., and then placing the fixed support having a tabular shape, etc., on this back support, 15 which is convenient.

[0079]

Then, the DC-DC converters and inverter of this embodiment will be explained in detail below.

[0080]

20 (DC-DC converter)

The DC-DC converter connected to the solar cell element generally consists of a voltage booster circuit which boosts a DC voltage to an input voltage of the inverter circuit, a control circuit which 25 controls start/stop of power conversion, optimization of operating points of the solar cell and operation mode, etc., a system-connected protection circuit, a

communication circuit and an input/output terminal, etc., and its output may be connected to a direct load. However, outputs of a plurality of solar cell elements are generally input to one inverter and 5 converted AC power is used for a load or interconnected.

[0081]

As the voltage booster circuit, various publicly known or publicly used circuit configurations can be 10 used irrespective of whether it is insulated or not. The control circuit comprises, for example, a CPU, PWM waveform control circuit, a maximum power point tracking control circuit, control power supply generation circuit, frequency/voltage reference 15 generator and switching control circuit, etc. Furthermore, the control circuit may also be made manipulatable from the outside through a communication cable, etc., or some functions of the control circuit may also be placed outside the DC-DC 20 converters to control a plurality of power conversion devices all together.

[0082]

However, to simplify the structure as much as possible, reduce the cost and improve reliability of 25 the DC-DC converters 2 in this embodiment, the control circuit preferably comprises at least a control power supply generation circuit, a switching

reference waveform generation circuit which specifies a switching frequency and a switching element drive circuit capable of driving the switching element at a fixed duty.

5 [0083]

Furthermore, the main circuit preferably comprises a switching element that is turned ON/OFF by the above described switching element drive circuit and a switching transformer created with a 10 predetermined turn ratio.

[0084]

In a system in which a plurality of DC-DC converters which drive the switching element at the above described fixed duty are connected in parallel, 15 it is possible to change an input voltage of the DC-DC converters by changing an input voltage of an inverter in the following stage and thereby move the operating point of the solar cell element.

[0085]

20 Furthermore, it is also possible to integrate the DC-DC converters on a single chip and make electrical connections to the surface wiring member and conductive substrate in steps of producing the solar cell element to thereby simplify a series of 25 operations for connecting the DC-DC converters to the solar cell element.

[0086]

The DC-DC converters are preferably installed near the solar cell element in such a way that the wiring loss is reduced so as to input the output from the solar cell element efficiently and preferably 5 directly attached to the solar cell element.

[0087]

Furthermore, exterior parts of the DC-DC converters should have properties such as heat resistance, humidity resistance, water resistance, 10 electrical insulation, low-temperature resistance, oil resistance, weather resistance, impact resistance, waterproofness, etc. The exterior parts should also be preferably made of material having good adhesiveness with an adhesive so as to be firmly 15 fixed to the solar cell element or back reinforcement member.

[0088]

With the above described elements taken into consideration, the exterior parts can be made of 20 plastics such as a resin, e.g., polycarbonate, polyamide, polyacetal, modified PPO (PPE), polyester, polyallylate, unsaturated polyester, phenol resin, epoxy resin, polybutylene terephthalate resin, nylon, etc., engineering plastics, or the like. Further, a 25 thermoplastic resin such as ABS resin, polypropylene, polyvinyl chloride or the like can also be used.

[0089]

Furthermore, when the DC-DC converters are attached to the light-receiving side, it is preferable to use carbon black as pigment or apply a resin paint for absorbing UV rays on the light-receiving surface to improve ultraviolet light resistance.

5 [0090]

(Inverter)

The inverter used in the photovoltaic power generating system generally comprises a voltage booster circuit which boosts an input DC voltage to an input voltage of an inverter circuit, the inverter circuit which converts DC power to AC power, a control circuit which controls start/stop of power conversion, optimization of an operating point of a solar cell and operation mode, etc., a system-connected protection circuit, a communication circuit and an input/output terminal, etc., and its output is used for a load or interconnected.

10 20 [0091]

As a voltage booster circuit, various publicly known or publicly used circuit systems can be used irrespective of whether it is insulated or not. As the inverter circuit, a voltage type inverter using an IGBT or MOSFET as a switching element is preferable. By driving the gate of the switching element through a control signal of the control

circuit, it is possible to obtain AC power having a desired frequency, phase and voltage.

[0092]

The control circuit is provided with, for 5 example, a CPU, PWM waveform control circuit, frequency/voltage reference generator, maximum power point tracking control circuit, current reference generator, mode switch and switching control circuit, etc. Furthermore, when a plurality of inverters of 10 this embodiment are connected to one solar cell element, the control circuit can also be made manipulatable from the outside through a communication wire, etc., and the control circuit itself can also be concentrated outside the inverter 15 to control the plurality of inverters all together.

[0093]

When the inverter of this embodiment is 20 electrically connected to the solar cell element, the inverter is preferably placed close to the solar cell element so as to input the output from the solar cell element efficiently and preferably directly connected to the solar cell element.

[0094]

Furthermore, there are two types of the inverter 25 3, with or without an insulating transformer, and either one can be used depending on its application. When an inter-device connection member between the

DC-DC converters and the inverter is grounded, an inverter having an insulating transformer is used.

[0095]

The inverter needs to have properties such as  
5 heat resistance, humidity resistance, water  
resistance, electrical insulation, low-temperature  
resistance, oil resistance, weather resistance,  
impact resistance, waterproofness, etc., according to  
its operating conditions. The inverter should also be  
10 preferably made of material having good adhesiveness  
with an adhesive so as to be firmly fixed to the  
solar cell element.

[0096]

With the above described elements taken into  
15 consideration, the exterior parts can be made of  
plastics such as a resin, e.g., polycarbonate,  
polyamide, polyacetal, modified PPO (PPE), polyester,  
polyallylate, unsaturated polyester, phenol resin,  
epoxy resin, polybutylene terephthalate resin, nylon,  
20 etc., engineering plastics, or the like. Further, a  
thermoplastic resin such as ABS rein, polypropylene  
or polyvinyl chloride can also be used.

[0097]

Furthermore, when the inverter is attached to  
25 the light-receiving side, it is preferable to use  
carbon black as pigment or apply a resin paint for  
absorbing UV rays on the light-receiving surface to

improve UV light resistance.

[0098]

Then, the method of producing the photovoltaic power generating apparatus and photovoltaic power generating system of this embodiment will be  
5 explained in detail.

[0099]

(Production method)

FIG. 6 is a schematic external view of the  
10 photovoltaic power generating system of this embodiment and reference numeral 602 denotes a solar cell element in the above described configuration, 2 denotes a DC-DC converter, 3 denotes an inverter, 4 denotes a load and 5 denotes a commercial system.

15 [0100]

More specifically, a roll of a cleaned long stainless steel substrate of 0.1 mm thick, 250 mm wide and 300 m long is transferred as the conductive substrate 10 first and a layer of Al containing 1% of  
20 Si was formed in a thickness of 5,000 Å as the lower electrode layer 11 using a sputtering method. Then, a p/i/n-type amorphous silicon semiconductor layer 12 was formed using PH<sub>3</sub>, SiH<sub>4</sub> and H<sub>2</sub> gases for an n-type semiconductor, SiH<sub>4</sub> and H<sub>2</sub> gases for an i-type  
25 semiconductor and B<sub>2</sub>H<sub>6</sub>, SiH<sub>4</sub> and H<sub>2</sub> gases for a p-type semiconductor, thereby forming the n-type semiconductor layer of 300 Å in thickness, the i-type

semiconductor layer of 4,000 Å in thickness and the p-type semiconductor layer of 100 Å in thickness by a plasma CVD method for each film formation apparatus through which the stainless steel substrate passed.

5 [0101]

Then, ITO having a film thickness of 800 Å was formed as the upper electrode layer 13 using resistance heating vapor deposition.

[0102]

10 Then, in order to divide the photovoltaic layer created in this way into a plurality of portions, an etching paste containing  $\text{FeCl}_3$  and  $\text{AlCl}_3$ , etc., was applied to the upper electrode to be divided using a screen printing method, heated and then cleaned, part 15 of the upper electrode was removed in a linear form, etching lines 115 of 1 mm wide were formed at intervals of 5,500 mm and a photovoltaic layer was formed separated by the etching lines.

[0103]

20 Then, as shown in FIG. 4, a polyimide substrate double-side adhesive tape 25 (200  $\mu\text{m}$  thick (base material 100  $\mu\text{m}$ )) was continuously pasted to one side on the light-receiving side of the conductive substrate as an insulating double-side adhesive tape 25 of 7.5 mm wide first.

[0104]

Then, a carbon wire consisting of a  $\phi 100 \mu\text{m}$

copper wire coated beforehand with a carbon paste was formed with a 5.6 mm pitch on the power generation area of the photovoltaic layer and the polyimide base material double-side adhesive tape 25 as the current collection electrode 14.

5 [0105]

Then, a silver-plated copper foil of 5 mm wide, 245 mm long and 100  $\mu\text{m}$  thick was placed on the polyimide base material double-side adhesive tape 25 as a light-receiving surface terminal member 16, heated and press-bonded simultaneously with the current collection electrode 14 under conditions of 200°C, approximately  $4 \times 10^5$  Pa (3 kgf/cm<sup>2</sup>), 180 sec.

10 [0106]

15 Furthermore, as shown in FIG. 5, a transparent thin film resin layer 23 was stacked on the light-receiving surface of the solar cell element by coating a fluororesin paint to a thickness of 100  $\mu\text{m}$  using a spray coating method. This transparent thin film resin layer was stacked in such a way that only the portion having photoelectric conversion characteristics (active area) for the incident light of the solar cell element was covered.

20 [0107]

25 Then, the transparent thin film resin layer was cut from the roll along the etching lines at intervals of 5,500 mm to obtain a solar cell element

602 (FIG. 6) having the transparent thin film resin layer formed on the conductive substrate.

[0108]

Furthermore, lead members (not shown) are  
5 connected to the light-receiving surface terminal member 16 and conductive substrate 10 as connection terminals to the DC-DC converter 2 and ten DC-DC converters 2 are adhered so as to cover a part of the light-receiving side terminal member 16 at an  
10 interval of 500 mm using a silicon adhesive, the above described lead members and the input terminals of the DC-DC converters 2 are connected inside the DC-DC converters 2, then a cover is put to the DC-DC converters 2 and in this way a photovoltaic power  
15 generating apparatus 601 provided with the DC-DC converters 2 as shown in FIG. 6 is formed.

[0109]

Then, the photovoltaic power generating apparatus 601 is pasted to the support 56 using an  
20 epoxy resin adhesive.

[0110]

Then, ten DC-DC converters 2 attached to the solar cell element 602 are connected one by one using a connection cable 24 and input to the inverter 3 all  
25 together.

[0111]

The connection cable 24 includes two positive,

negative electric wires and each cable is electrically connected to the output terminals of the DC-DC converters inside the DC-DC converters and is also electrically connected to the cable connected to 5 the neighboring DC-DC converters.

[0112]

Using the same method, the photovoltaic power generating apparatuses 601 are mounted in ten support bodies 56 one by one using the same method and these 10 outputs are converted to AC power through the inverter 3 and supplied to the load 4 or system 5.

[0113]

(Explanation of operation)

Here, using the DC-DC converter 2 shown in FIG. 15 7 and the circuit diagram of the inverter 3 shown in FIG. 8, the main circuits and control circuits and their respective operations will be explained in detail.

[0114]

20 In the DC-DC converter 2 shown in FIG. 7, the output power of the solar cell element is stored in a capacitor 28 through input terminals 27 of the DC-DC converter 2 and converted to AC power by turning ON/OFF the MOSFETs 29 and 30 alternately.

25 [0115]

Then, the AC power input to a switching transformer 31 is converted to AC power with a

predetermined transformation ratio (1:175 in this embodiment), further rectified by a diode bridge 32, passed through a filter capacitor 33 and then output from the DC-DC converter 2 to the inverter 3.

5 [0116]

Though not used in this embodiment, a coil for filtering may also be provided between the diode bridge 32 and filter capacitor 33 and both the filter capacitor and coil for filtering may also be omitted  
10 depending on the configuration of the system.

[0117]

Then, a control circuit 34 of the DC-DC converter 2 will be explained. The control circuit 34 of this embodiment consists of a control power supply generation circuit 35, a reference waveform generation circuit 36 and a MOSFET driver 37, the input of the control power supply generation circuit 35 is connected to both ends of the capacitor 28 and the control signal output of the MOSFET driver 37 is  
15 connected to the gates of the MOSFETs 29 and 30.  
20

[0118]

A detailed operation of the control circuit 34 will be shown below. When the voltage of the solar cell element 1 reaches the starting voltage of the  
25 control power supply generation circuit 35, the output voltage of the control power supply generation circuit 35 is input to the reference waveform

generation circuit 36 and MOSFET driver 37.

[0119]

Then, the reference waveform generation circuit 36 operates first, a preset square wave at a reference frequency is input to the waveform input section of the MOSFET driver 37, gate drive signals S1 and S2 are input from the MOSFET driver 37 to the gates of the MOSFETs 29 and 30 to thereby turn ON/OFF the MOSFETs 29 and 30 at a fixed duty alternately.

10 [0120]

Furthermore, as shown in FIG. 8, the main circuit of the inverter 3 is constructed of input terminals 38 to which output power of a plurality of DC-DC converters 2 is input, a smoothing capacitor 39, a full bridge circuit 41 made up of transistors 40a, 40b, 40c and 40d, a coil 42 and a capacitor 43.

15 [0121]

Furthermore, the control circuit of the inverter 3 is divided into portions controlling start/stop of power conversion, optimization of an operating point of the solar cell and operation modes, etc., but only portions related to PWM control in connection with the present invention will be explained in detail using FIG. 9 here.

20 [0122]

As shown in the figure, the PWM control section is constructed of an input voltage detection circuit

45, a band pass filter (BPF) 46, an output current detector 47 (shown in FIG. 8), a DC voltage constant control circuit 48, a DC voltage reference voltage source 49, a multiplier 50, an output current control 5 error amplifier 51, a PWM modulation circuit 52 and a gate drive circuit 53 which drives transistors 40a to 40d of the full bridge circuit 41.

[0123]

Furthermore, a specific method of PWM control is 10 as follows. First, the input voltage detection circuit 45 detects an inverter input voltage  $V_{DC}$ , the DC voltage constant control circuit 48 generates an error signal S7 indicating a difference between the inverter input voltage  $V_{DC}$  and a reference voltage  $V_{ref}$  15 of the DC voltage reference voltage source 49 and uses this error signal S7 as one input to the multiplier 50. Furthermore, a commercial system voltage  $V_{cs}$  is detected, the BPF 46 extracts a fundamental component and uses a reference sine wave 20 signal S8 thereof as the other input to the multiplier 50. The multiplier 50 multiplies the input error signal S7 by the reference sine wave signal S8 to generate an inverter output current reference signal S9.

25 [0124]

Furthermore, the error amplifier 51 receives the inverter output current reference signal S9 from the

multiplier 50 and inverter output current  $I_{out}$  detected by the output current detector 47 as inputs and outputs a modulation reference error signal S10 that is obtained by amplifying the difference between 5 the two to the PWM modulation circuit 52. The PWM modulation circuit 52 performs PWM control based on the input modulation reference error signal S10, drives the transistors 40a to 40d by gate drive signals S3 to S6 through the gate drive circuit 53 10 and controls the transistors so as to obtain an inverter input voltage  $V_{DC}$  which matches the reference voltage  $V_{ref}$ .

[0125]

15 The operation of the full bridge circuit is well known and so explanations thereof will be omitted here.

[0126]

20 Thus, when the outputs of a plurality of DC-DC converters 2 which perform a switching operation on the MOSFETs at a fixed duty to perform control in such a way that the boosting voltage ratio is constant are connected to the inverter 3 which performs input voltage constant control, the DC-DC converters 2 operate at a constant input voltage. 25 This is because the DC-DC converters which perform boosting voltage ratio constant control at a fixed duty act as an impedance converter, and as a result

perform control in such a way that the operating voltage of the solar cell element becomes constant.

[0127]

That is, when the input voltage of the inverter 5 is set to 175 V in this embodiment, the output voltages of all the DC-DC converters 2 connected to the input side of the inverter 3 become substantially 175 V and the operating voltage of the solar cell element operates at approximately 1 V which is an 10 optimum operating voltage according to the boosting voltage ratio of the switching transformer.

[0128]

The case where the inverter 3 performs input voltage constant control has been so far explained, 15 but by using a current detection circuit (not shown) for the input section of the inverter, it is also possible to measure electric power from the voltage and current of the inverter input section and control the input voltage of the inverter so as to perform 20 maximum power point tracking control to maximize the magnitude of this electric power.

[0129]

In this case, it is possible to change the input voltages of the DC-DC converters 2 by changing the 25 input voltage of the inverter 3, that is, change the output voltage of the solar cell element, and therefore even in the case where sunlight changes, it

is possible to set an output voltage of the solar cell element only through maximum power follow-up control of the inverter 3 so that the input power to the inverter 3 becomes a maximum.

5 [0130]

As shown above, this embodiment forms a long solar cell element with a large area on a conductive substrate, eliminates a cutting step, end etching step, serial connection step and bypass diode connection step, etc., which are necessary to manufacture a conventional, general solar cell module, and can thereby reduce production and material costs and considerably improve the efficiency of area power generation of the photovoltaic power generating apparatus.

15 [0131]

Furthermore, the work of setting solar cell elements at regular intervals can easily be carried out by simply mounting a photovoltaic power generating apparatus having a long solar cell element with a large area formed on a single conductive substrate on the support. Thus, compared to the conventional mounting work of mounting and connecting solar cell elements one by one, this embodiment can drastically shorten the time required to mount the photovoltaic power generating apparatus and reduce the mounting cost.

[0132]

Furthermore, this embodiment connects a plurality of DC-DC converters in parallel to a long solar cell element with a large area formed on a single conductive substrate, and therefore, compared to the conventional configuration in which a plurality of solar cell elements are connected in parallel by wiring members and their outputs are connected to the inverter all together, if the voltage boosting ratio at the DC-DC converter is assumed to be approximately  $n$  times, it is possible to reduce current-collection loss to the order of  $(1/n)^2$  when wiring of the same cross-sectional area (same resistance value). This makes it possible to considerably reduce the cross-sectional area of the member connecting the DC-DC converters in parallel, drastically reduce the material cost, reduce its weight and improve ease of mounting.

[0133]

In addition, the absence of serially connected solar cell elements limits influences of partial shadows only to the DC-DC converters in the vicinity of the area where partial shadows have occurred and has no influence on other DC-DC converters. This makes it possible to construct a photovoltaic power generating system with considerably small influences of partial shadows compared to conventional serially

connected solar cell elements. When compared to the conventional system with the same power generation capacity, this effect becomes more noticeable in proportion to the capacity of power generation.

5 [0134]

Furthermore, in the above-described conventional system having serially connected solar cell elements, the presence of variations in the output characteristics of the individual solar cell elements 10 causes solar cell elements having poor output characteristics to influence other solar cell elements, leading to an output reduction of the entire photovoltaic power generating system. On the other hand, the photovoltaic power generating system 15 of this embodiment is constructed of a single solar cell element on a conductive substrate, a semiconductor layer, electrode layer, etc., on a single conductive substrate can be obtained through continuous film formation, which reduces variations in the characteristics of the solar cell element 20 caused by production and considerably reduces variations in the output characteristics.

[0135]

Thus, the photovoltaic power generating system 25 of this embodiment can achieve special effect of reducing loss due to shadow loss or loss by characteristic variations, which could not have been

attained conventionally.

[0136]

Furthermore, the DC-DC converters connected to the solar cell element are controlled to a fixed 5 voltage boosting ratio at a fixed duty and the inverter connected in parallel to a plurality of such DC-DC converters performs input voltage constant control or maximum power point tracking control, and one inverter can thereby control operating points of 10 the respective solar cell elements, simplify the control sections of the respective DC-DC converters, improve reliability and reduce the cost.

[0137]

Furthermore, in the case of the conventional 15 photovoltaic power generating system having serially connected solar cell elements, if such live parts are exposed, for example, a mode is given in which environment resistant coating of the solar cell element is simplified and/or the member connecting 20 solar cell elements serially or in parallel is used exposed without insulating coating, which causes the following problems.

[0138]

That is, electrodes and wiring members of the 25 solar cell elements and at least some live parts of the member connecting the solar cell elements serially or in parallel are exposed and not insulated,

and so they are placed in a damp and wet condition (state in which the resistance between the solar cell element live part and ground is reduced by water content) due to rainwater, etc., and with subsequent  
5 solar radiation, a leakage current path is formed in paths such as [solar cell element live part] - [rainwater] - [damp and wet support] - [rainwater] - [ground] or [solar cell element live part] - [rainwater] - [ground].

10 [0139]

This results in a problem that metal ions constituting the live parts flow out from the live parts and promote corrosion of the electrodes, wiring members or serial or parallel connection members. It  
15 is known that especially when copper is used for the serial or parallel connection members, a current path is formed and copper is ionized and eluded considerably, drastically reducing the life of the connection members.

20 [0140]

That is, in the above described conventional photovoltaic power generating system, if a plurality of solar cell elements are serially connected, at the end closest to the positive electrode of the serially  
25 connected body, the potential difference from ground increases considerably, facilitating progress of corrosion of the connection members. To cope with

this problem, the solar cell elements may be connected in parallel, but in this case, as the number of solar cell elements connected in parallel increases, the current that flows also increases.

5 Since the current-collection loss is proportional to the square of the current, there is a problem that trying to suppress the current-collection loss to a certain value or below will increase the cross-sectional area of the parallel connection members  
10 considerably.

[0141]

In order to promote a further cost reduction, this embodiment also connects a plurality of DC-DC converters to one solar cell element even when the 15 photovoltaic power generating system has a structure with an exposed live part. This drastically reduces the potential of the solar cell element with respect to the potential of ground compared to the conventional system with serial connection, and can 20 thereby prevent corrosion of wiring members from advancing and improve reliability.

[0142]

(Second embodiment)

A second embodiment of the photovoltaic power 25 generating system according to the present invention will be explained below. Explanations of the same parts as those of the first embodiment will be

omitted and characteristic parts of this embodiment will be principally explained below.

[0143]

5 FIG. 10 is an external view showing a schematic configuration of the second embodiment and FIG. 11 is an equivalent circuit diagram of the second embodiment.

[0144]

10 As a solar cell element 1 of this embodiment, substantially the same one as that of the first embodiment is used and detailed explanations thereof will be omitted.

[0145]

15 FIG. 12 is an enlarged view of a connection portion between the solar cell element 1 and DC-DC converter 2 of this embodiment. Here, the position in the solar cell element at which the DC-DC converter 2 is attached is the same as that of the first embodiment, but the second embodiment is different in 20 that an output terminal 59 is drawn out of the exterior part of the DC-DC converter 2.

[0146]

25 The output terminal 59 is a terminal member connected to a high voltage side output terminal of the DC-DC converter 2 and the interior of the DC-DC converter 2 is filled with a filler to prevent water, etc., from entering the DC-DC converter 2 through the

outlet of this output terminal 59.

[0147]

Furthermore, the same circuit in the first embodiment explained with reference to FIG. 7 is used 5 as the internal main circuit of the DC-DC converter 2 in this embodiment, but as shown in the circuit diagram in FIG. 13, this embodiment electrically connects the primary low voltage side terminal of the switching transformer 31 and the secondary low 10 voltage side terminal to the conductive substrate 10 of the solar cell element 1 to thereby cause the primary low voltage side to have the same potential as the secondary low voltage side.

[0148]

15 Then, as shown in FIG. 14, a copper band 62 having a cross-sectional area of  $0.1 \text{ mm}^2$  is laid beforehand as a parallel connection member on the support 56 using an epoxy-based adhesive, the solar cell element provided with the DC-DC converters 2 is 20 adhered and fixed to the support 56 using an epoxy-based adhesive and output terminals 59 which are drawn out of the DC-DC converters 2 are electrically connected to the copper band 62 one by one.

[0149]

25 Furthermore, an inter-device wiring member 63 on the low voltage side is connected to the conductive substrate 10, this inter-device wiring member 63 and

copper band 62 are input to the inverter 3, DC power output from each DC-DC converter 2 is converted to AC power and interconnected to a load or a commercial system.

5 [0150]

This embodiment uses a high-frequency link type inverter 64 as shown in FIG. 15 as the inverter 3. This inverter 64 converts the DC output from the DC-DC converter 2 to high-frequency AC by a high-frequency inverter 65, applies insulation by a small high-frequency transformer 66, converts the AC to DC by an AC/DC converter 67 and further converts it to AC at a commercial frequency by a DC/AC converter 68 and outputs the AC.

10 [0151]

15 Then, this embodiment grounds a copper band 62 as shown in FIG. 10 to complete a photovoltaic power generating system. That is, in the configuration of this embodiment, the respective DC-DC converters 2 are electrically united through a conductive substrate 10 of the solar cell element 1, and therefore one of the output terminals of each DC-DC converter is wired on the conductive substrate and has an excellent feature that only a single wiring member suffices to connect the DC-DC converters.

20 [0152]

25 Furthermore, for a cost reduction, this

embodiment adopts a technique of only coating the active area with a transparent thin film resin layer without using any sealing member.

[0153]

5        As described above, by grounding the copper band 62 which is a parallel connection member, the copper band 62 which is the high voltage side of the parallel connection member has a zero potential with respect to the ground as illustrated in the  
10      equivalent circuit diagram of the photovoltaic power generating system in FIG. 11.

[0154]

15      Therefore, the low voltage side of the parallel connection member becomes a negative potential with respect to the ground and the conductive substrate 10 connected thereto also has the same potential and the low voltage side of the solar cell element 1 also becomes a negative potential.

[0155]

20      At this time, the voltage at both ends of the solar cell element 1 is smaller than the potential difference between the copper band 62 and conductive substrate 10 and the member on the high voltage side such as a light-receiving surface terminal member of  
25      the solar cell element 1 is also kept to a negative potential with respect to the ground, and it is thereby possible to prevent corrosion of the wiring

member from advancing.

[0156]

This embodiment uses Cu for the parallel connection member 62 and inter-device wiring member 63, but as a property of copper, it is known that copper is easily eluded when a positive potential is applied as shown in the potential-pH diagram shown in FIG. 16. In view of this property, this embodiment is designed to always keep the wiring member made of copper to zero or negative potential with respect to the ground to prevent elusion of copper.

[0157]

As shown above, according to the photovoltaic power generating system of this embodiment, in addition to the effect obtained in the first embodiment, the potentials of the solar cell element and wiring member with respect to the ground are zero or negative potential, which prevents corrosion of the wiring electrodes, etc., and has the effect of improving reliability.

[0158]

(Third embodiment)

A third embodiment of the photovoltaic power generating system according to the present invention will be explained below. Explanations of the same parts as those of the first embodiment and second embodiment will be omitted and characteristic parts

of this embodiment will be principally explained below.

[0159]

A solar cell element used in this embodiment has  
5 substantially the same configuration as that used in  
the first embodiment, but it is different only in a  
stacked configuration of the semiconductor layer.

[0160]

More specifically, on a roll-shaped, cleaned,  
10 long stainless steel substrate of 0.1 mm thick as a  
conductive substrate, a layer of Al containing 1% of  
Si was formed using a sputtering method in a film  
thickness of 5,000 Å as a lower electrode layer. Then,  
15 an n/i/p-type amorphous silicon semiconductor layer  
was formed using B<sub>2</sub>H<sub>6</sub>, SiH<sub>4</sub> and H<sub>2</sub> gases for a p-type  
semiconductor, SiH<sub>4</sub> and H<sub>2</sub> gases for an i-type  
semiconductor and PH<sub>3</sub>, SiH<sub>4</sub> and H<sub>2</sub> gases for an n-type  
semiconductor, thereby forming the p-type  
semiconductor layer of 100 Å in thickness, the i-type  
20 semiconductor layer of 4,000 Å in thickness and the  
n-type semiconductor layer of 300 Å in thickness,  
respectively one by one by a plasma CVD method.

[0161]

Then, another n/i/p-type amorphous silicon  
25 semiconductor layer was stacked to form a double  
configuration layer.

[0162]

Then, ITO having a film thickness of 800 Å was formed as an upper electrode layer using resistance heating vapor deposition to form a solar cell element.  
[0163]

5       Then, using the same steps as those in the first embodiment from here on, one solar cell element was completed on the conductive substrate. Then, a plurality of DC-DC converters are connected to this solar cell element at regular intervals.

10      [0164]  
          Since this embodiment uses an n/i/p-type amorphous silicon semiconductor layer for the solar cell element, unlike the first embodiment, the conductive substrate side becomes the high voltage side of the solar cell element. Furthermore, as shown in FIG. 19, inside the main circuit of the DC-DC converter 2, the primary high voltage side of the switching transformer 31 and the secondary high voltage side are electrically connected to the conductive substrate 10 of the solar cell element 1801, and in this way the primary high voltage side has the same potential as the secondary high voltage side.

20      [0165]  
25       Then, as in the case of the second embodiment, the photovoltaic power generating apparatus is mounted on a support 56, further connected to an

inverter 3 and the conductive substrate 10 is grounded in this embodiment to obtain a photovoltaic power generating system of this embodiment as shown in FIG. 17.

5 [0166]

As the inverter 3, a high-frequency link type inverter is used as in the case of the second embodiment.

[0167]

10 This embodiment uses a bare copper band as a low voltage side member 62 of a parallel connection member, but one with an insulating coat can also be used preferably.

[0168]

15 For a cost reduction, this embodiment adopts a technique of coating only the active area where no sealing member is used with a transparent thin film resin layer and the overall circuit configuration of the photovoltaic power generating system can be 20 expressed as shown in FIG. 18.

[0169]

As shown in the equivalent circuit diagram of the photovoltaic power generating system in FIG. 18, by grounding the conductive substrate 10, which is a 25 common electrode to the respective solar cell elements 1801, high voltage sides of the solar cell elements 1801 and inter-device wiring member 63

become zero potential with respect to the ground.

[0170]

Therefore, all other wiring members are kept to a negative potential with respect to the ground, and 5 in this way it is possible to prevent corrosion of the wiring member from advancing.

[0171]

Thus, according to the photovoltaic power generating system of this embodiment, in addition to 10 the effect obtained in the first embodiment, the potentials of the solar cell element and wiring member with respect to the ground become zero or negative potential, which produces the effect of preventing corrosion of wiring electrodes, etc., and 15 improving reliability.

[0172]

(Embodiment 4)

A fourth embodiment according to the present invention will be explained below. Explanations of 20 the same parts as those of the first to third embodiments will be omitted and characteristic parts of this embodiment will be principally explained below.

[0173]

25 FIG. 20 shows part of a solar cell element used in the photovoltaic power generating apparatus of this embodiment. As shown in the figure, a solar cell

element 1 used in this embodiment has a configuration similar to that of the solar cell element in the first to third embodiment, but the conductive substrate is provided with mounting sections 130 with 5 no semiconductor layer at both ends of the conductive substrate.

[0174]

The specific producing method is the same as that in the first embodiment, a roll-shaped cleaned 10 long stainless steel substrate of 0.1 mm thick is used as a conductive substrate, a lower electrode layer, a semiconductor layer and an upper electrode layer are stacked on a conductive substrate with 20 mm margins from both ends of the conductive substrate 15 and the area where these layers are not provided is used as mounting sections 130.

[0175]

Then, as shown in FIG. 20, by linearly removing the area between the upper electrode layer and 20 mounting sections 130 to separate the mounting sections 130 from the live sections, etching lines 131 are formed.

[0176]

Furthermore, as in the case of the first 25 embodiment, DC-DC converters 2 are mounted to construct a photovoltaic power generating apparatus, and this is then mounted on a support.

[0177]

In this embodiment, concrete nails are put in the mounting sections 130 by a tacker at 30 cm intervals to fix the DC-DC converters to the support.

5 [0178]

As the support, a concrete material is used, but the support can also be formed of wood, plastics, etc., and in that case, the support can be fixed using nails and screws, etc.

10 [0179]

Thus, this embodiment adopts a configuration that further facilitates the mounting of the photovoltaic power generating apparatus and can thereby reduce its mounting cost.

15 [0180]

(Fifth embodiment)

A fifth embodiment according to the present invention will be explained below. Explanations of the same parts as those of the above-described 20 embodiments will be omitted and characteristic parts of this embodiment will be principally explained below.

[0181]

FIG. 21 shows a schematic configuration of this 25 embodiment, and as shown in the figure, a photovoltaic power generating apparatus 2001 of this embodiment consists of a plurality of DC-DC

converters 2004 connected to a solar cell element 2002.

[0182]

As the solar cell element 2002 used in this 5 embodiment, one similar to the solar cell element before carrying out a step of applying the transparent thin film resin layer of the second embodiment is used and the plurality of the DC-DC embodiment is used and the plurality of the DC-DC converters 2004 are electrically connected to a 10 light-receiving surface terminal member 2005 and conductive substrate.

[0183]

Furthermore, output terminals (not shown) of each of the DC-DC converters are electrically 15 connected to the terminal member 2005 whereby all the DC-DC converters 2004 are connected in parallel.

[0184]

In this embodiment, the entire solar cell element assembly is sealed with resin by means of a 20 weather resistant film, filler and back member with the DC-DC converters connected. FIG. 22 is a cross-sectional view along a line X-X' in FIG. 21 and reference numeral 2006 denotes a weather resistant film, 2007 denotes a filler, 2008 denotes a back member, 2009 denotes a light-receiving surface 25 terminal member and 2010 denotes a double-side adhesive tape.

[0185]

As a specific example of the material used for this sealing, ETFE (ethylene tetrafluoroethylene) is preferable for the weather resistant film 2006, EVA (ethylene-vinyl acetate copolymer, weather resistant grade) is preferable for the filler 2007 and PVF/Al/PVF sheet, etc., is preferable for the back member 2008.

[0186]

As the sealing method, the stacked body consisting of a back member, filler, solar cell element assembly, filler and weather resistant film stacked in that order is created by melting the filler at 150°C using a vacuum laminator.

[0187]

At this time, the terminal member 2005 drawn out of the solar cell element assembly is exposed from the end of the sealing member, and it is possible to use this terminal member 2005 to make an electrical connection with an adjacent photovoltaic power generating apparatus or an inverter.

[0188]

The photovoltaic power generating apparatus of this embodiment can produce effects similar to those of the second embodiment.

[0189]

(Other embodiments)

The photovoltaic power generating system according to the above described embodiments of the present invention is intended to supply power to a commercial power system, but it goes without saying 5 that the photovoltaic power generating system of the present invention may also be used to supply power to an AC power system other than a commercial AC power system such as self AC power generation equipment at a factory, etc.

10 [0190]

[Effect of the Invention]

As described above, according to the present invention, because a photovoltaic power generating apparatus is constructed using a single long-size 15 solar cell element with a large area, those steps including cutting, end etching, serial connection, and bypass diode connection required for production of the conventional, general solar cell modules become unnecessary, which leads to reductions of 20 production and material costs and improvement in the efficiency of area power generation of the photovoltaic power generating apparatus.

[0191]

Furthermore, because the work of mounting solar 25 cell elements at regular intervals can be carried out with a photovoltaic power generating apparatus being used as a unit, thereby drastically shortening the

time required for mounting the photovoltaic power generating apparatus and reducing the cost required for the mounting.

[0192]

5       In addition, the influences of partial shadows are limited only to the power conversion devices involved in the shadowed areas and have no influence on other power conversion devices.

[0193]

10      Further, since the photovoltaic power generating apparatus is constructed of only a single solar cell element on the substrate, it is possible to obtain a semiconductor layer and electrode layer, etc., on one conductive substrate by continuous film formation.

15      This can considerably reduce influences of partial shadows and variations in the characteristics compared to a conventional system having serially connected solar cell elements.

[0194]

20      Moreover, it is possible to drastically reduce the current collection loss, thereby considerably reducing the cross-sectional area of the member connecting DC-DC converters in parallel, drastically reducing the material costs, lessening the weight and 25     improving ease of mounting.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a

configuration of a photovoltaic power generating system according to a first embodiment of the present invention;

5 FIG. 2 illustrates a schematic configuration of a conventional, general photovoltaic power generating system;

FIG. 3 is a cross sectional view showing a configuration example of the solar cell element of FIG. 1;

10 FIG. 4 illustrates a schematic configuration of the solar cell element of FIG. 1;

FIG. 5 illustrates a step of producing the solar cell element of FIG. 1;

15 FIG. 6 is an external view showing an outline of the photovoltaic power generating system according to the first embodiment of the present invention;

FIG. 7 is a circuit diagram showing an example of a DC-DC converter;

20 FIG. 8 is a circuit diagram showing an example of an inverter;

FIG. 9 illustrates a PWM control system of the inverter according to the present invention;

25 FIG. 10 is an external view showing an outline of a photovoltaic power generating system according to a second embodiment of the present invention;

FIG. 11 is a circuit diagram showing a schematic configuration of the photovoltaic power generating

system of FIG. 10;

FIG. 12 is an enlarged view showing a connecting portion of an individual solar cell element and a DC-DC converter of FIG. 10;

5 FIG. 13 is a circuit diagram showing a connection of a main circuit of the DC-DC converter of FIG. 10 and the conductive substrate of the solar cell element;

10 FIG. 14 illustrates a method of mounting the photovoltaic power generating system of FIG. 10;

FIG. 15 illustrates a schematic configuration of an inverter of high-frequency link type used in the photovoltaic power generating system of FIG. 10;

15 FIG. 16 illustrates a potential-pH diagram of copper;

FIG. 17 is an external view showing an outline of a photovoltaic power generating system according to a third embodiment of the present invention;

20 FIG. 18 is a circuit diagram showing a schematic configuration of the photovoltaic power generating system of FIG. 17;

25 FIG. 19 is a circuit diagram showing a connection of a main circuit of the DC-DC converter of FIG. 17 and the conductive substrate of the solar cell element;

FIG. 20 is an external view showing an outline of a photovoltaic power generating apparatus

according to a fourth embodiment of the present invention;

FIG. 21 is an external view showing an outline of a photovoltaic power generating apparatus  
5 according to a fifth embodiment of the present invention; and

FIG. 22 is a cross sectional view along a line X-X' in FIG. 21.

[Explanation of Reference Numerals]

10 1, 602, 1801, 2002: solar cell element  
2, 2004: DC-DC converter  
3: inverter  
4: load  
5: commercial system  
15 6: solar cell module  
7: solar cell array  
8: photovoltaic power generating system  
9: current collection box  
10: conductive substrate  
20 11: lower electrode layer  
12: semiconductor layer  
13: upper electrode layer  
14: current collection electrodes  
16: light receiving surface terminal member  
25 23: transparent thin film resin layer  
24: connection cable  
25: insulating double-side adhesive tape

27: input terminal  
28: capacitor  
29, 30: MOSFET  
31: switching transformer  
**5** 32: diode bridge  
33: filter capacitor  
34: control circuit of DC-DC converter  
35: control power supply generation circuit  
36: reference waveform generation circuit  
**10** 37: MOSFET driver  
38: input terminal  
39: smoothing capacitor  
40a-40d: transistor  
41: full bridge circuit  
**15** 42: filter coil  
43: filter capacitor  
45: input voltage detection circuit  
46: band pass filter (BPF)  
47: output current detector  
**20** 48: DC voltage constant control circuit  
49: DC voltage reference voltage source  
50: multiplier  
51: output current control error amplifier 5  
52: PWM modulation circuit  
**25** 53: gate drive circuit  
56: support  
59: output terminal

62: copper band  
63: inter-device wiring member  
64: high-frequency link type inverter  
65: high-frequency inverter  
5 66: high-frequency transformer  
67: AC/DC converter  
68: DC/AC converter  
401, 501: solar cell assembly  
106, 601, 2001: photovoltaic power generating  
10 apparatus  
115, 131: etching line  
130: mounting section  
401, 501: solar cell assembly  
2005: terminal member  
15 2006: weather resistant film  
2007: filler  
2008: back member  
2009: light-receiving surface terminal member  
2010: double-side adhesive tape

[NAME OF DOCUMENT] ABSTRACT

[Abstract]

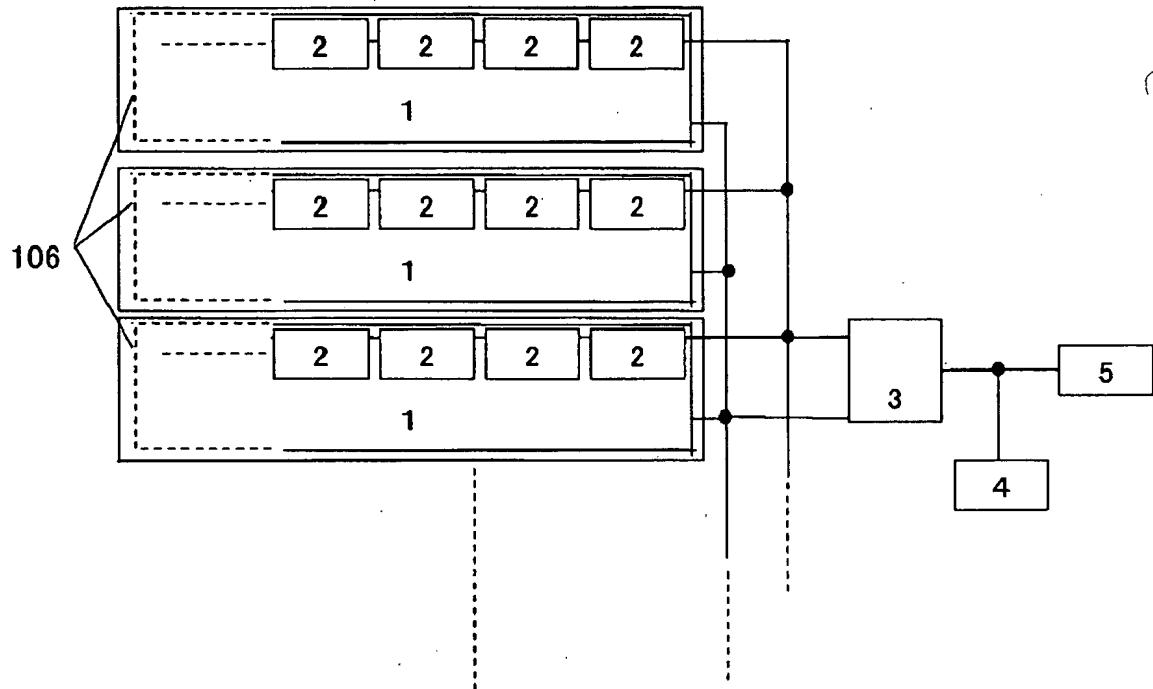
[Problem to Be Solved] To provide a photovoltaic power generating apparatus that has a simple structure and can reduce the production cost as well as the influences of partial shadows and variations in the characteristics.

[Means for Solving Problem] A photovoltaic power generating apparatus comprises a single solar cell element 1 formed on a substrate and a plurality of power conversion devices 2 connected to the solar cell element 1 for converting an output of the solar cell element.

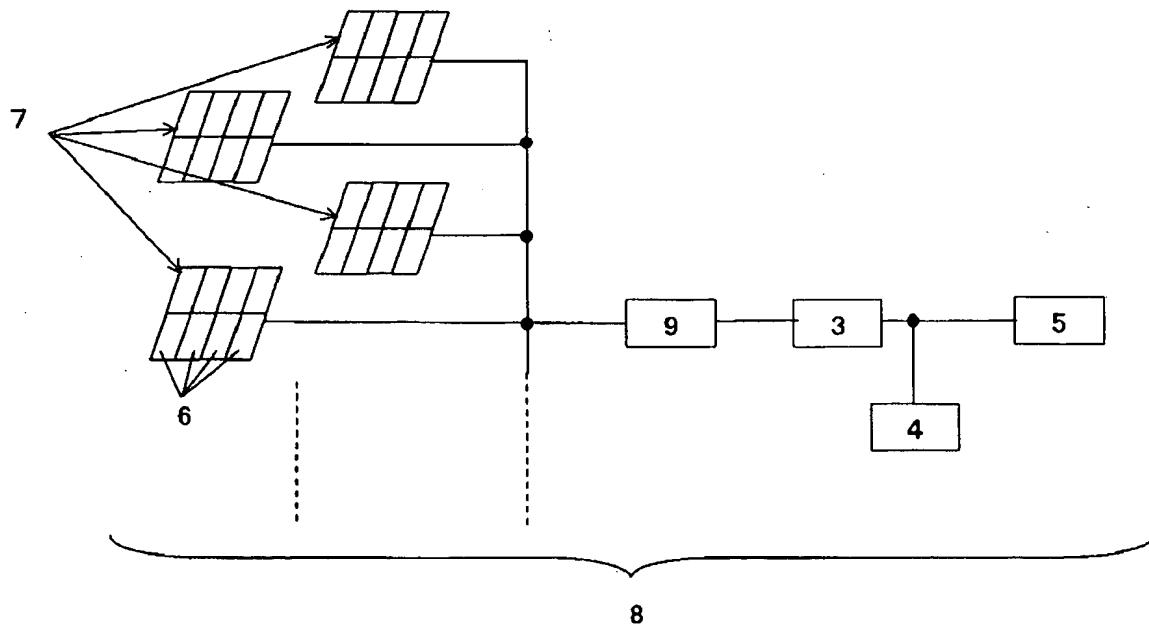
[Elected Figure] Fig. 1

【書類名】 図面

【図1】



【図2】

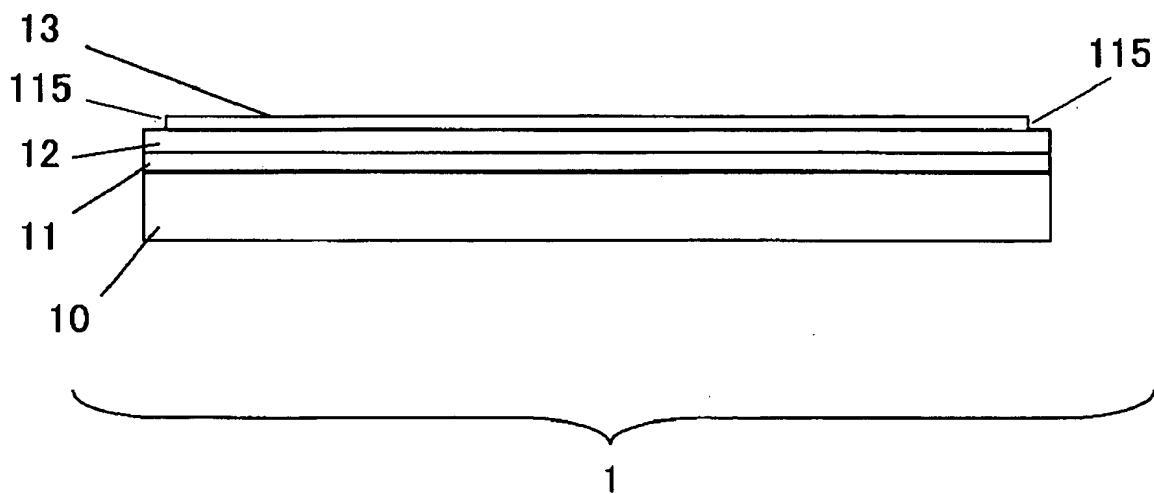


提出日 平成14年11月25日

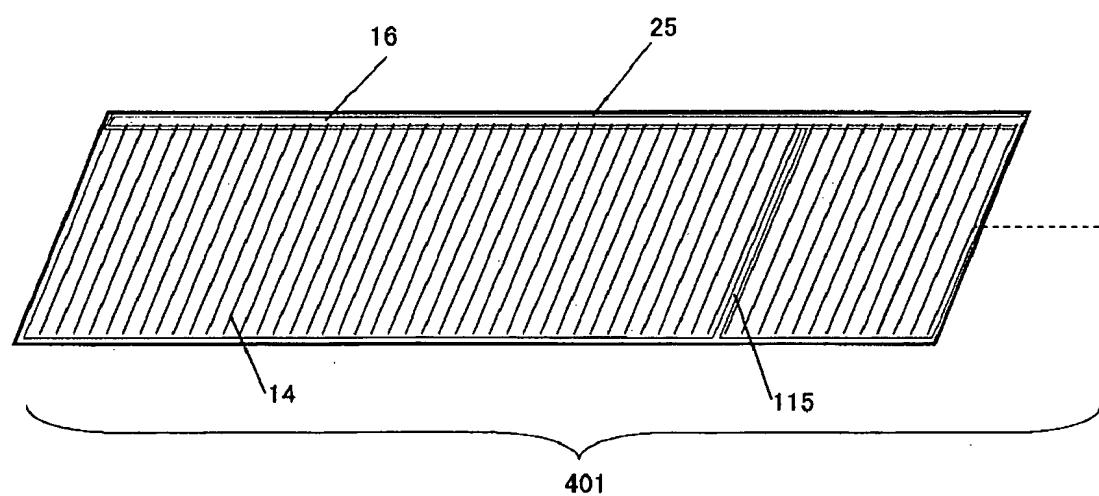
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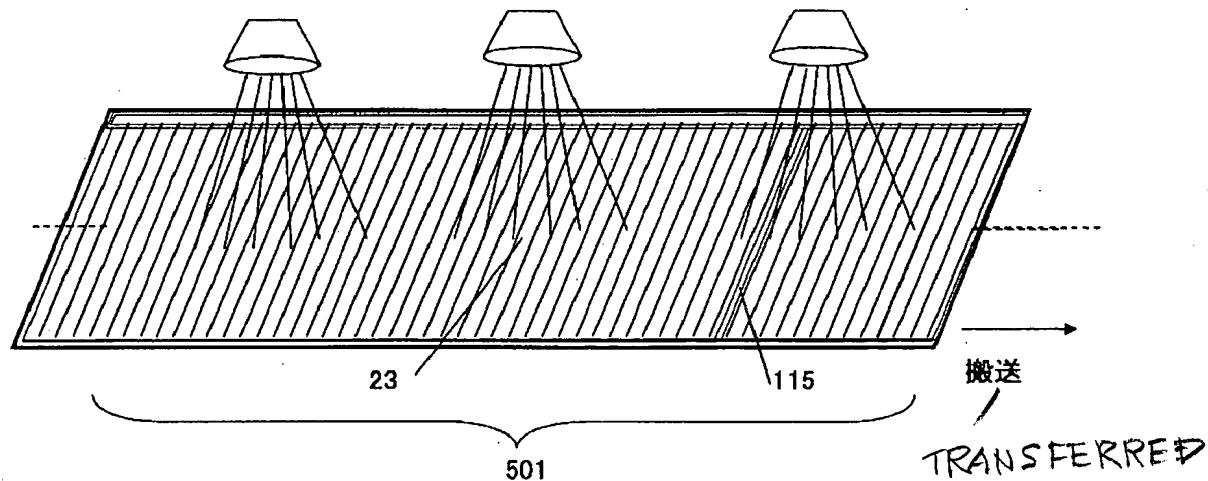
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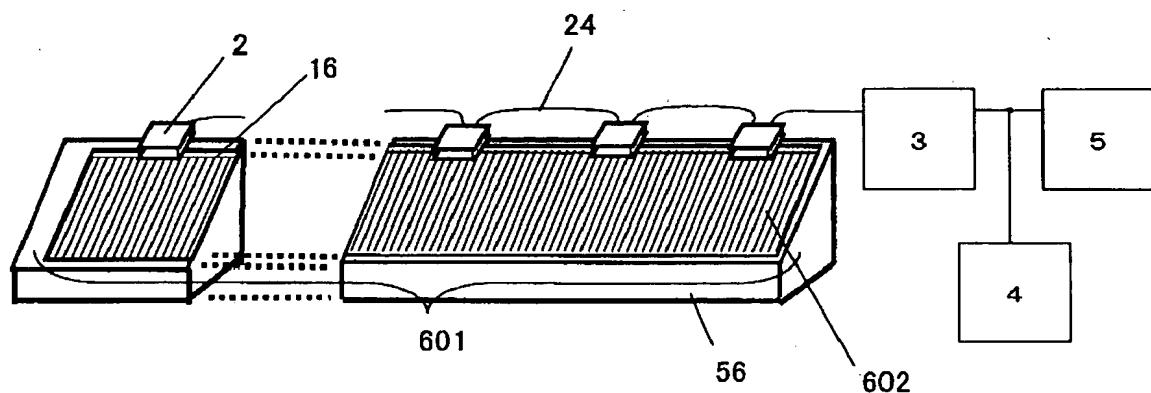
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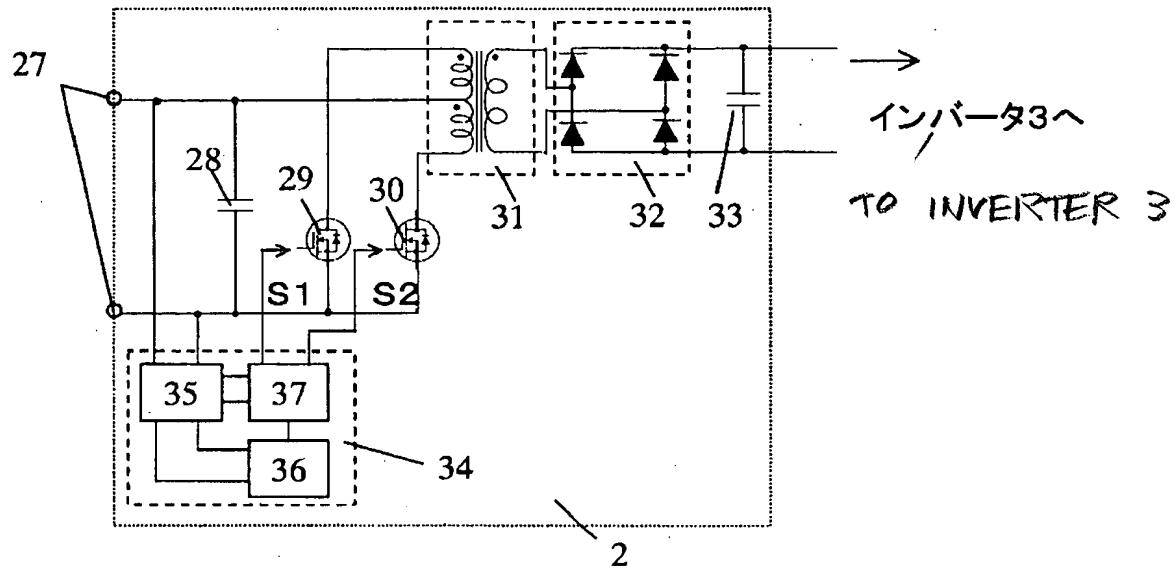
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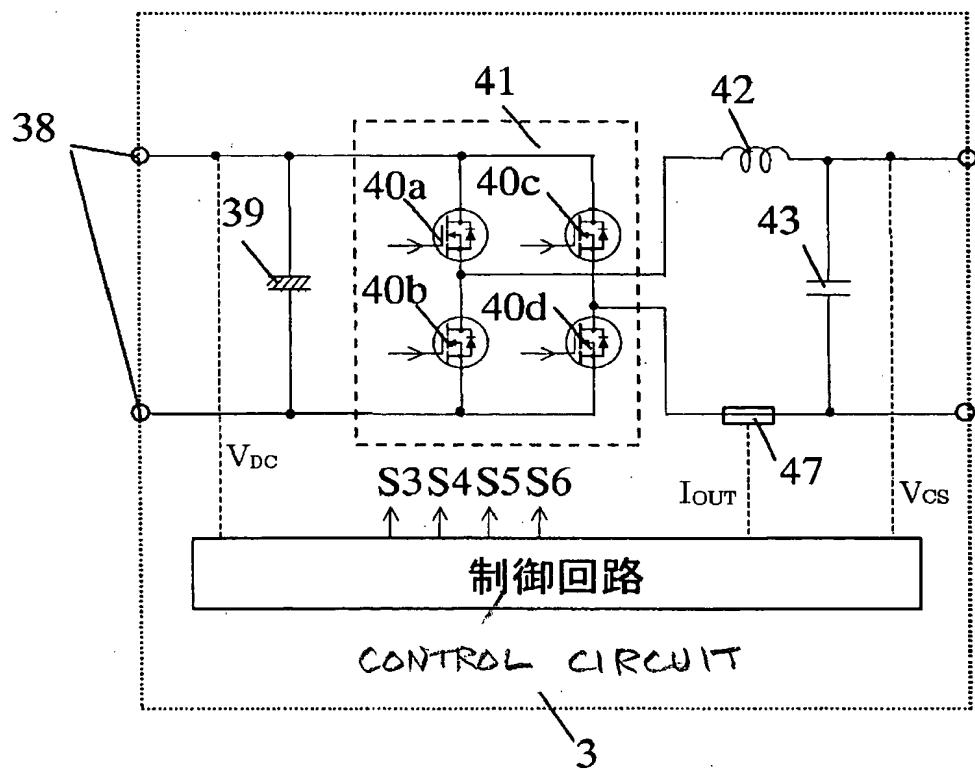
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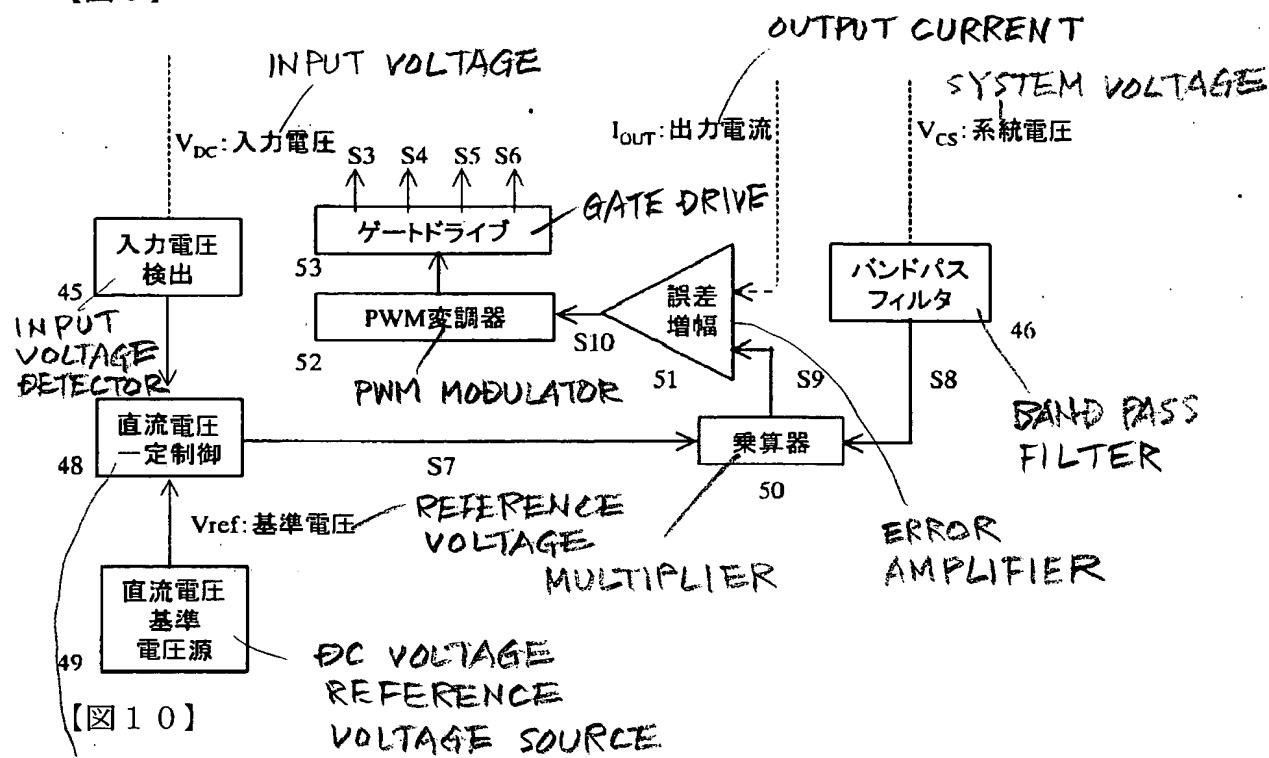
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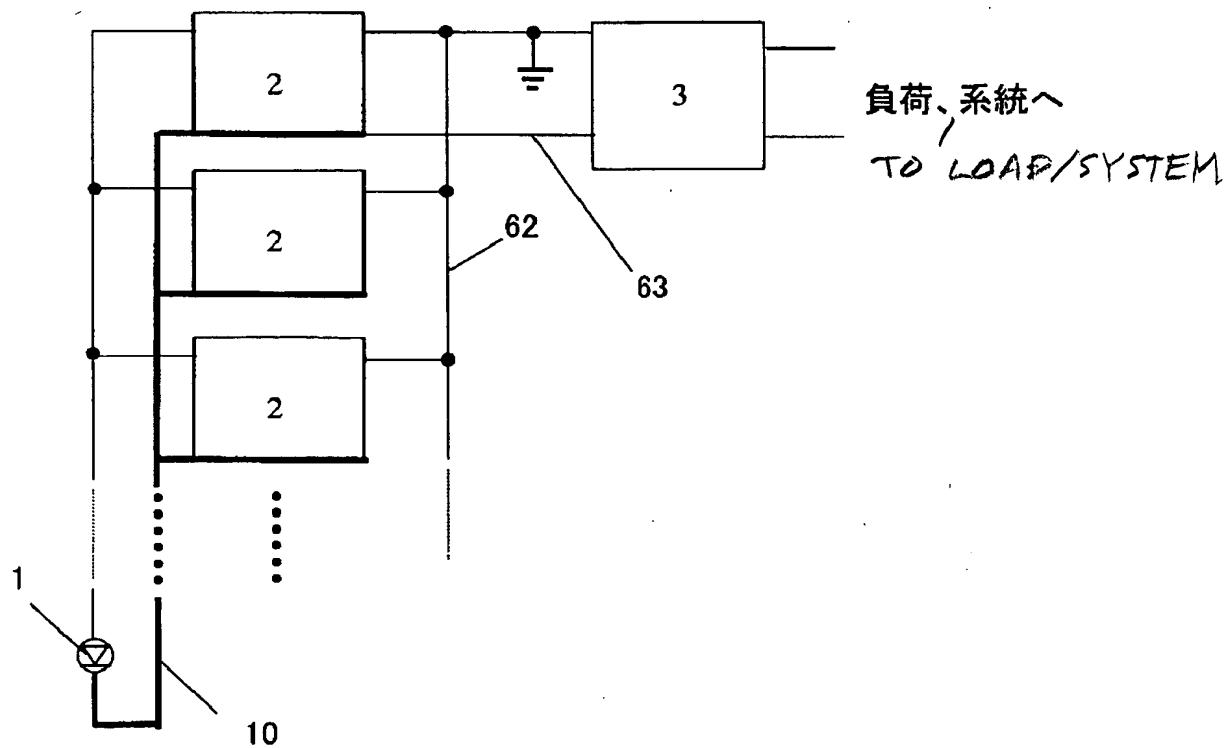
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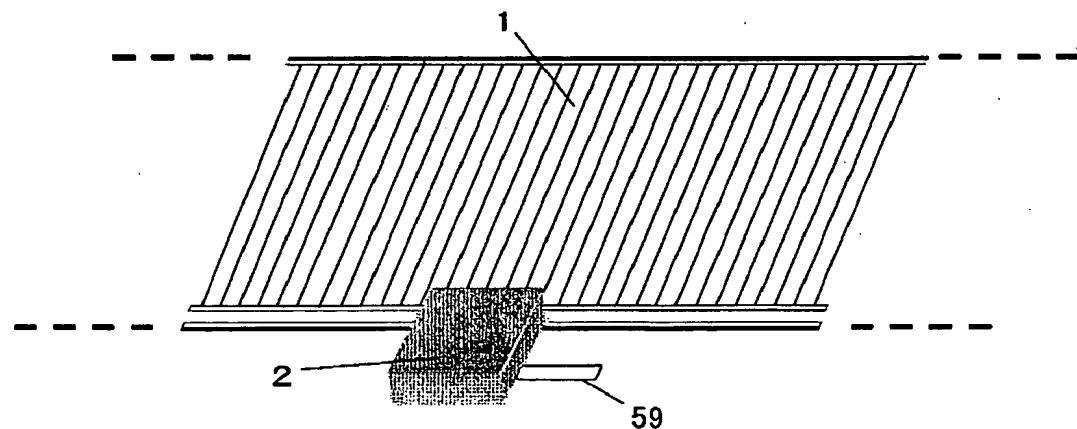
【図9】



【図11】



【図12】

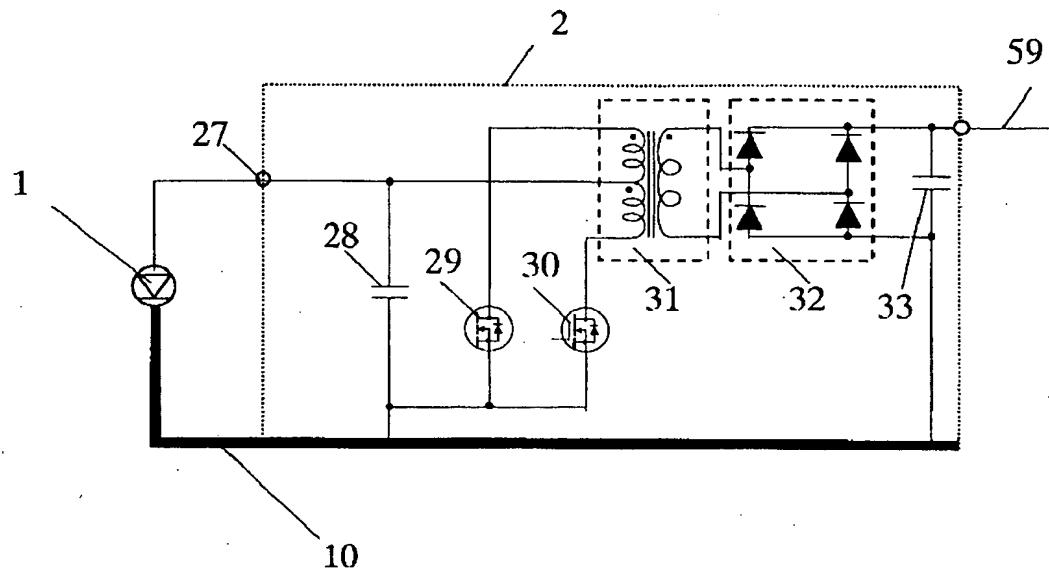


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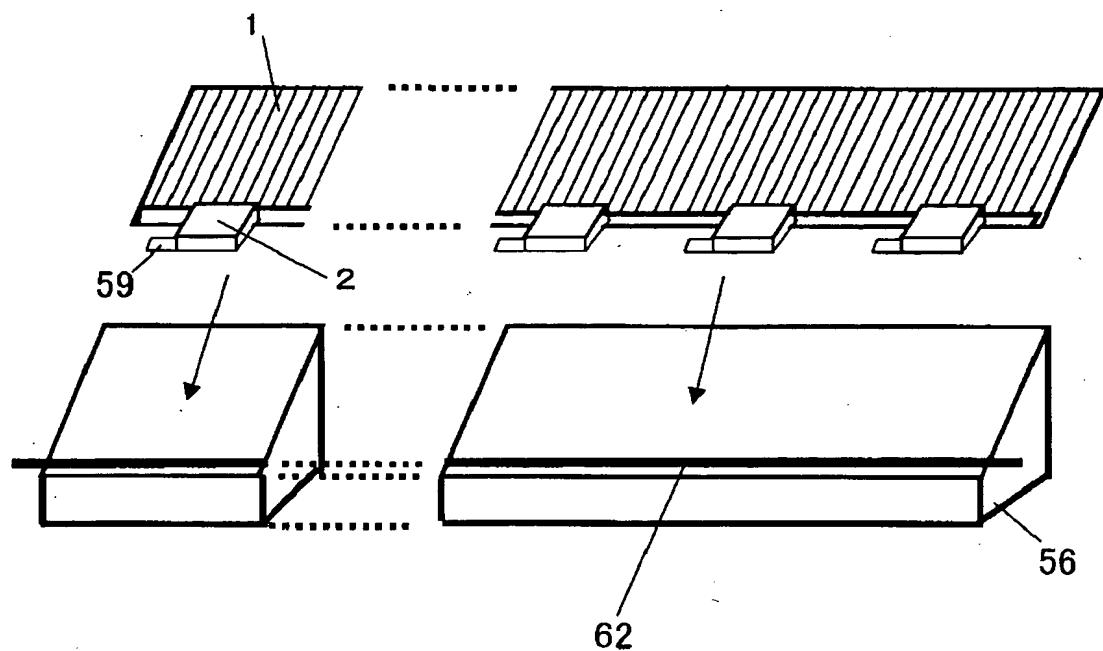
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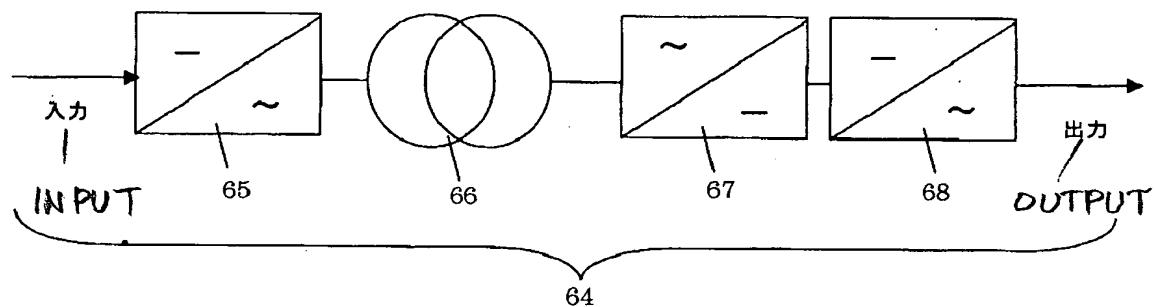
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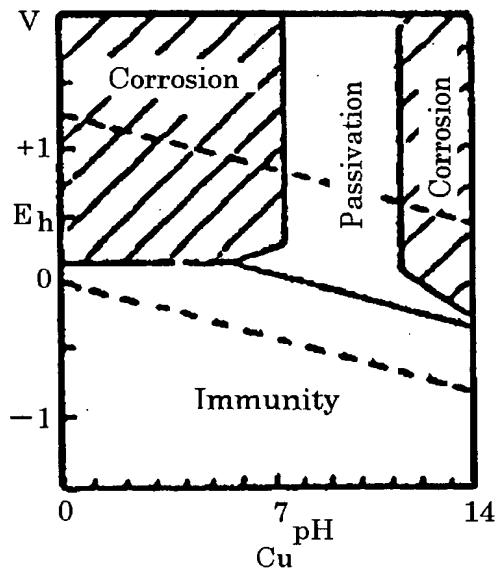
【図14】



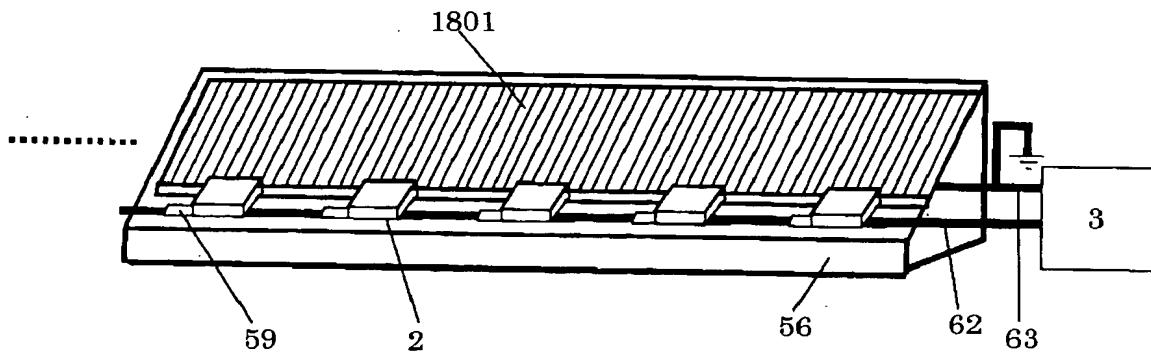
【図15】



【図16】



【図17】

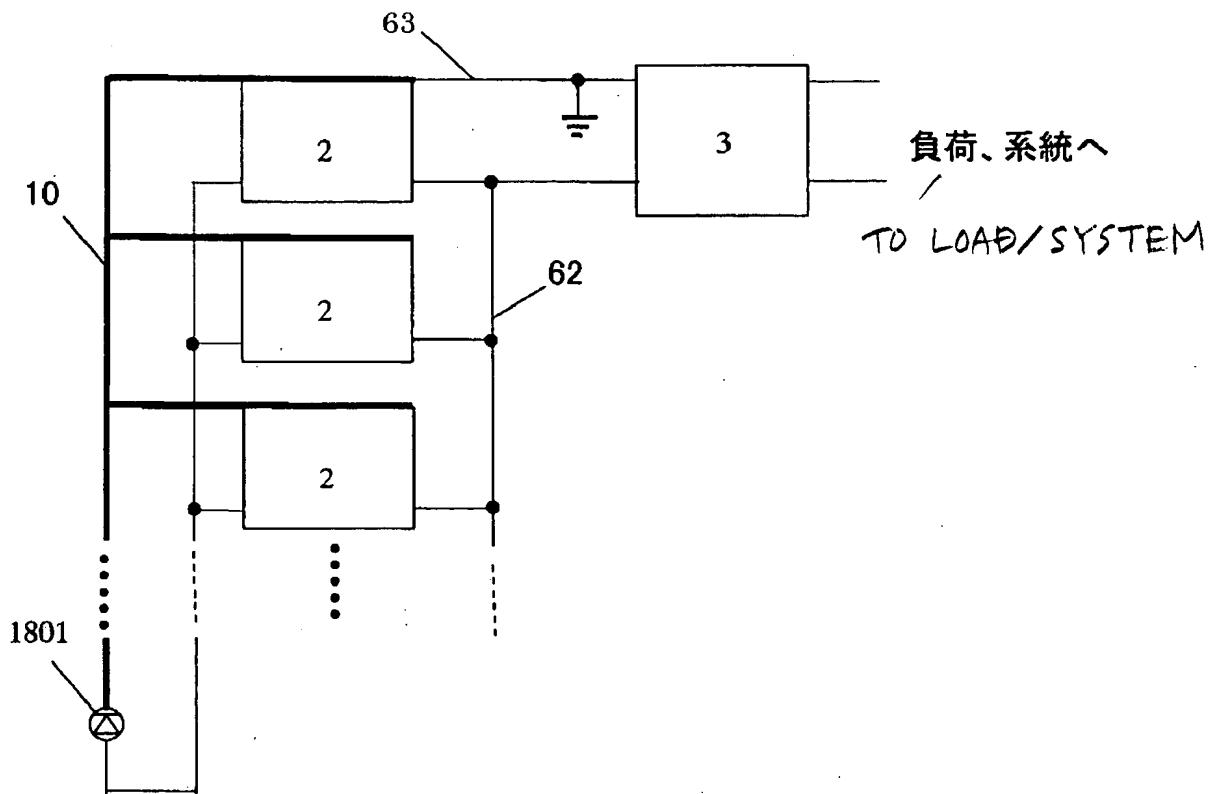


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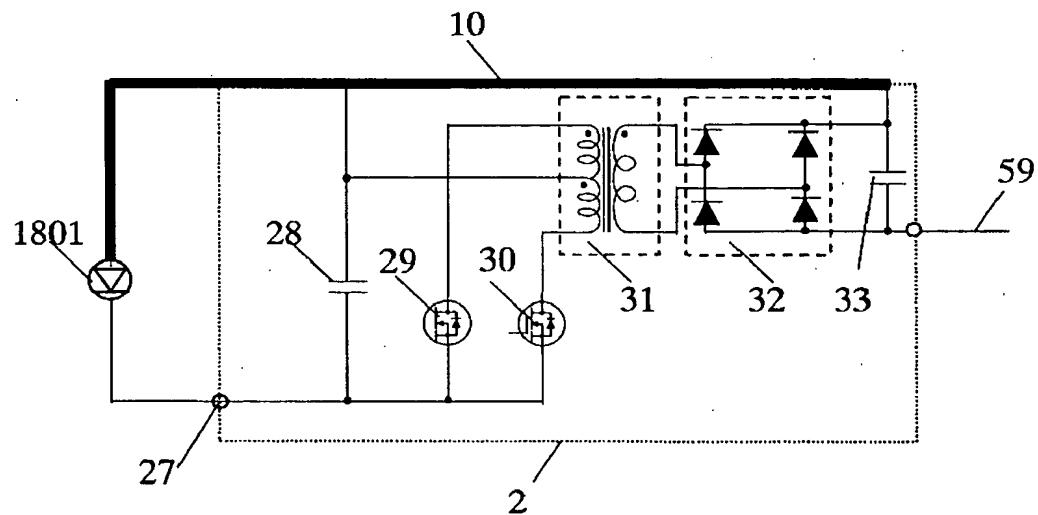
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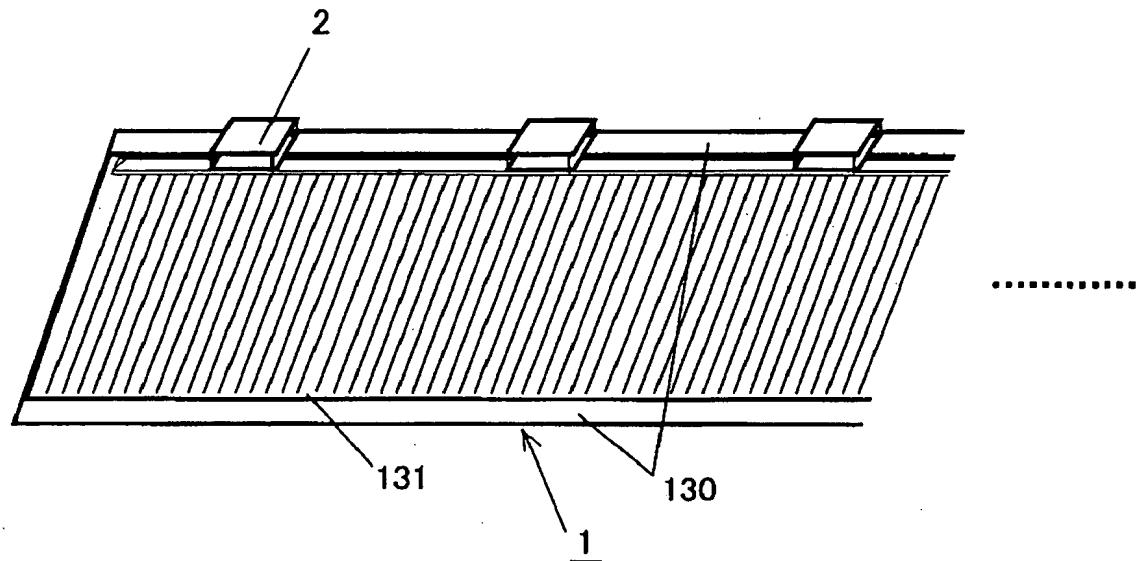
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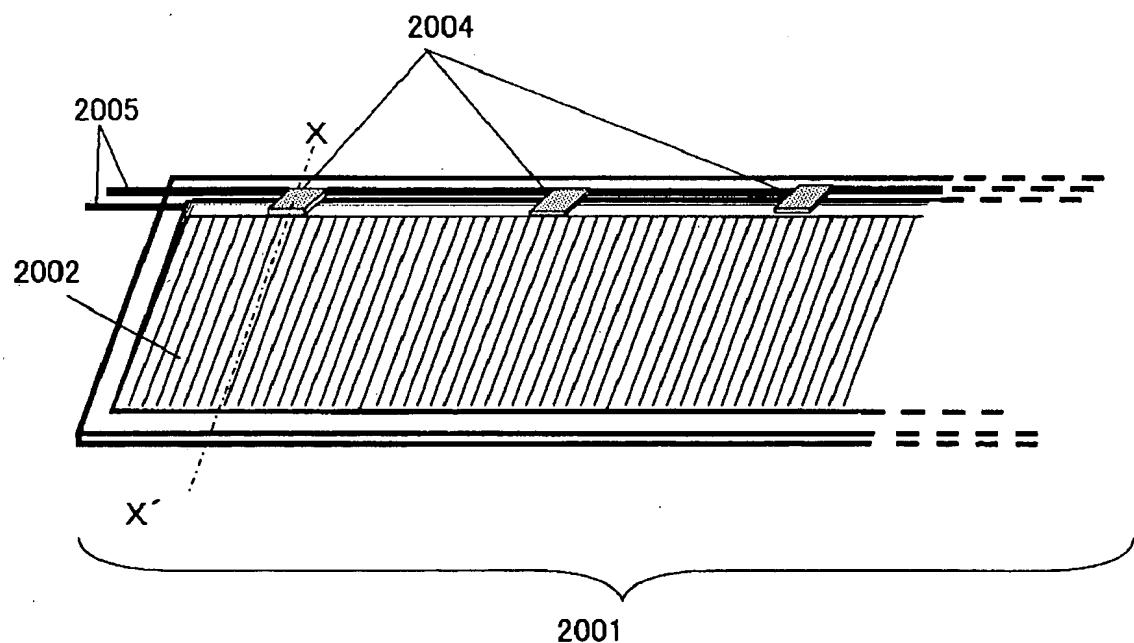
【図19】



【図20】



【図21】

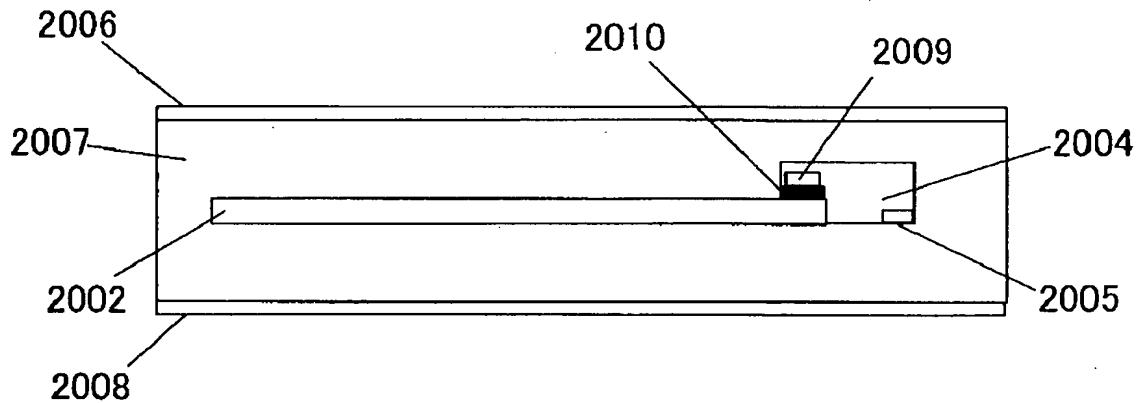


提出日 平成14年11月25日

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【図22】



提出日 平成14年11月25日

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整理番号=226754

【書類名】 要約書

【要約】

【課題】 構成が簡単で製造コストを低減すると共に、部分影や特性のばらつきの影響を低減することができる太陽光発電装置を提供する。

【解決手段】 基板上に形成された一つの太陽電池セル1と、この太陽電池セル1に接続され、太陽電池セルからの出力を変換する複数の電力変換装置2とを備えることを特徴とする。

【選択図】 図1